DISCOVERY

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Monthly Notebook

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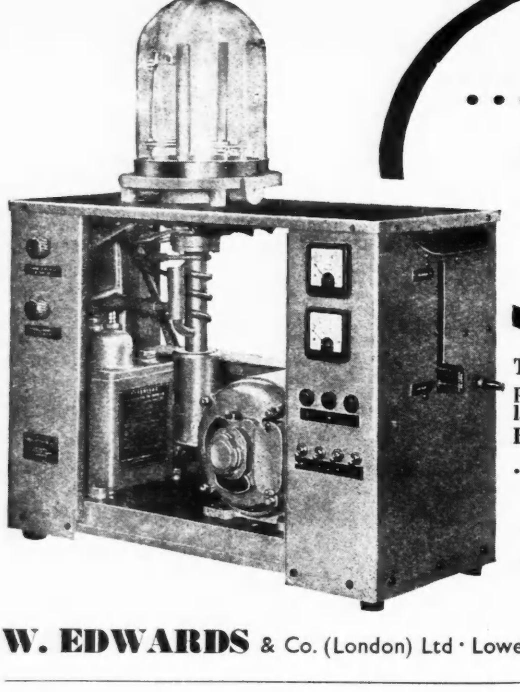

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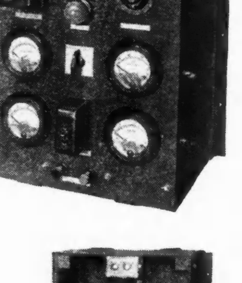

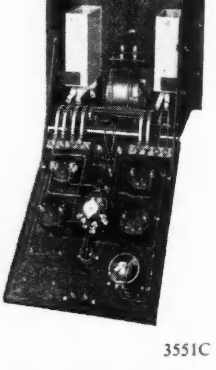

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THE MAGAZINE OF SCIENTIFIC PROGRESS

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The Progress of Science

An Atomic Flash in the Pan

PRESUMABLY in order to divert attention from his scandalous seizure of *La Prensa* which used to be the *Manchester Guardian* of Argentina, Juan Perón held a very special press conference at Easter. At this it was announced that scientists in Argentina, using only relatively cheap home-produced materials (the equivalent perhaps of Argentine pig swill) had succeeded on February 16 in producing "controlled liberation of atomic energy".

"The new Argentina," said Perón, had decided that it was not "worth the trouble to copy nuclear fission". Instead, said Perón (according to *Time*), "contrary to what was done in foreign experiments, Argentine technicians worked on the basis of thermonuclear reactions, which are identical with those whereby the sun releases atomic energy".

The *Time* report quotes the Argentines as saying that the experiment was conducted at an atomic plant on Huemul Island in the Andean lake of Nahuel Huapí, about 900 miles south-west of Buenos Aires. The Argentines claimed that it was achieved without either uranium or plutonium! Perón stated that, "with the seriousness and veracity which is my custom", this wonderful supply of atomic energy would be used "solely for power plants. smelters and other industrial establishments".

The oddest feature of this press conference was that members of the foreign press were barred. The story was clearly intended to be for home consumption only, so even Perón must have thought that nobody abroad could possibly swallow it. (Certain British Sunday papers fell for the story, a rather unfortunate lapse which can scarcely be excused by the difficulty of obtaining technical advice over the Easter holidays.)

The scientist who has gained the more than doubtful honour of being credited with the 'discovery' was Dr. R. Richter, an Austrian-born scientist formerly with the German University of Prague. Richter has said that "what we have accomplished is strictly Argentine—it is infinitely superior to the system used in the U.S.A. For some time now Argentina has known the secret of the hydrogen bomb (but) I have always found a refusal on General Perón's part to make use of this secret." Questioned about its explosive possibilities, he said that it would depend on the weather whether such an explosion would be audible.

Asked whether the sound of an alleged explosion was heard 6½ miles away from where he conducted the explosion, he said—a little naïvely, one feels—"No".

Best comment on the whole episode came from Dr. Ralph E. Lapp, former head of the Office of Naval Research: "I know what that other material is that the Argentines are using. *It's baloney.*" Or is it just possible that Perón and Richter were both suffering from artificial sunstroke caused by a thermonuclear reaction identical with that whereby the sun releases atomic energy?

Fifty Years of Nobel Prizes

THE story of the discoveries made by the scientists who have won Nobel Prizes provides a potted history of the progress of science since 1900. In connexion with the recent 50th anniversary of the Nobel Foundation, a truly excellent book about Nobel and his prizewinners has been published.* It is not only a first-class compilation of unique and permanent value, but it sets a new and very high standard for translation from Swedish into English.

Many of the details in the book have the appeal of novelty, since they have not hitherto been easily accessible in Britain. There is, for instance, the full story of the Nazi ban on Germans accepting Nobel Prizes, a story which spotlights the inevitable enmity that must exist between scientists and totalitarian politicians.

The whole sordid story began with the award of a Peace Prize to Carl von Ossietzky, who had been arrested after the Reichstag fire and incarcerated in a concentration camp where he was to die in 1938 from tuberculosis. After this award—"a brave deed at a time when leading circles in many countries smoothed the way for Fascism with their talk of a 'correct attitude', obviously without realising what consequences such an attitude of mental neutrality to the enemies of democracy might entail"—Hitler issued a decree forbidding Germans to accept any Nobel Prize.

In October 1939, a month and a half after World War II

* *Nobel, the Man and His Prizes*: edited by the Nobel Foundation. (Sohlmans Forlag, Stockholm, 1950, 620 pages).

had started, the Caroline Medico-Chirurgical Institute of Stockholm, which decides how the Prizes for medicine and physiology shall be awarded, came to the unanimous conclusion that the discovery of the antibacterial properties of prontosil—first of the sulpha drugs—merited a Nobel Prize. The judges were convinced that German scientists would welcome this award, regardless of the Führer's edict. Unfortunately the German Legation in Stockholm got to hear about the proposal to award the prize to Gerhard Domagk, and the next thing to happen was the arrival of a telegram to the Swedish Foreign Office from that misnamed department of the Nazi State, the *Kulturministerium*. This stated that the award of a Nobel Prize to a German was "completely unwanted"—*durchaus unerwünscht*. In spite of this veiled threat, the Caroline Institute decided by a large majority to give the 1939 prize to Gerhard Domagk.

But that decision was only the beginning of trouble for Domagk. On November 3, 1939, he wrote acknowledging the honour. But on November 23 he wrote again, this time refusing the prize in terms which indicated quite clearly that he had been intimidated by the Nazis into refusing the prize. In the second letter he wrote that he had acted in ignorance when he acknowledged the award: "I did not know however what was the reason for this prohibition (on Germans receiving Nobel awards) and to what circumstances it was due. Not until just now have I been informed that in the autumn of 1936 the Nobel Committee in Oslo awarded the Peace Prize to Carl von Ossietzky, who had been convicted of high treason, and that the intentionally hostile gesture towards National Socialist Germany implied in this award was the cause of a special decree by the Führer and Reich Chancellor in which the above prohibition was promulgated. Under these circumstances I must ask that my letter of the 3rd instant, which was sent in ignorance of the true situation, be regarded as not having been sent. To my regret I can no longer regard the action of the Caroline Institute as an expression of honour for my work, but, on the contrary, I must assume that the Institute, to whom the reasons for the German decree must undoubtedly have been known, expected me simply to disregard the injunction. Such a lack of respect would seem to every German the equivalent of an act of disloyalty which I must severely condemn. I therefore feel obliged to decline the prize."

The Swedes realised that Domagk had been forced to decline the honour under pressure, and had they ever been in doubt on this matter the receipt of similar letters of refusal from Prof. Richard Kun of Heidelberg and Prof. Adolf Butenandt of Berlin (awarded the Nobel Prizes for Chemistry in 1938 and 1939 respectively) would have made it quite clear how adamant the Nazis were whenever it seemed possible that a German scientist ran any risk of being awarded some prize of *international* significance!

What sort of pressure had the Nazis put on Domagk? Actually a fortnight after he had written that original letter of acknowledgment to the Caroline Institute, he was arrested by the Gestapo, who demanded all papers connected with the Nobel Prize award, including whatever newspaper clippings in regard to it had been sent Prof. Domagk from abroad. He was taken to police headquarters, and locked in a cell after he had been relieved of his "pocket-book, watch, penknife, collar, tie and a few other things". After a week in gaol and after questioning by a senior SS-officer, he was released. "No reason for my arrest was given, only vague hints that my letter to Sweden had been couched in too friendly terms."

Later Domagk was informed by Prof. Wirtz of Munich, who was well in with the Nazis, that "the Führer had become extremely upset when he heard about the award of the Nobel Prize. When he tried to get information from his medical entourage about my work and no one was able to inform him, he probably assumed that it had been given for some forbidden international relationship and then ordered my immediate arrest." Prof. Wirtz did offer to intercede for Domagk with the authorities with a view to obtaining redress for the injustice he had suffered. Domagk, however, did not feel he could avail himself of this offer: "No amends could be made for what had been done to me, and I did not want to ask for any favours. For that reason I avoided after that all relations with the Party, in so far as it was possible to do so without further endangering my family."

Not long afterwards he was again arrested by the Gestapo. This was done at the Potsdam railway station, just before he was due to give a lecture before an international medical conference in Berlin. "Apparently, I was to be prevented from coming into contact with the foreign physicians who might ask me about the Nobel Prize matter. Later I learned that when my lecture was to have been given and the audience was waiting, no one knew that I was not to speak, and my would-be hearers waited in vain; in the newspapers the excuse was given that the lecture had had to be omitted because of illness. . . . After this arrest I knew I was being watched in everything I did or said, and that every new suspicion aroused against me might be fatal both to myself and my family. No apology was ever made for what had happened."

All of which demonstrates the contempt with which science and culture are treated in totalitarian states. The Nazi who said that whenever he heard the word 'culture' he felt for the trigger of his revolver epitomised the fear of the totalitarian for true knowledge, a fear which accounts for the lengths to which totalitarians will go in order to suppress truth and scientific facts. Unfortunately, what happened in Germany during the Nazi régime is happening elsewhere at the present time. But let us hope that the time is not far off when the barriers which some governments have erected in order to prevent the free collection and circulation of scientific information will be destroyed along with such stupid bans as the one the Nazis imposed on Nobel Prizes.

Underground Gasification

THE Ministry of Fuel's underground gasification experiments in Derbyshire (last commented upon in these columns in August 1950) have now reached another important stage in their development.

It will be recalled that this process, enabling coal to be converted into fuel gas *in situ* can be worked in two principal ways; they are known as the *streaming* and *percolation* methods respectively (see diagrams on next page).

The first experiments last year at Newman Spinney, near Chesterfield, were based on *streaming* methods, necessitating the boring of an underground gallery in the thickness

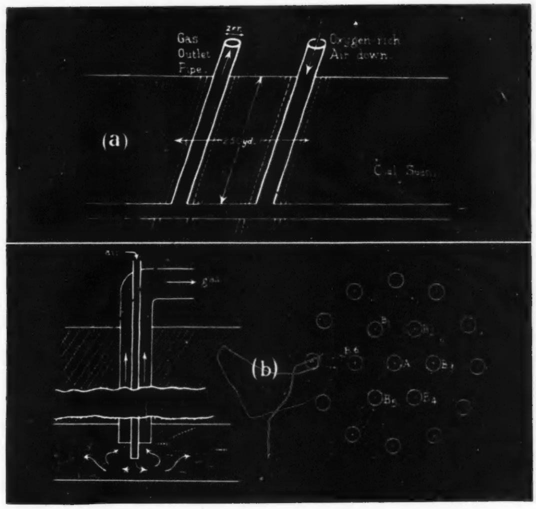
of the seam, met by two or more vertical boreholes reaching down from the surface. The original plan of igniting the coal by lowering thermite incendiary bombs down one of the shafts did not prove successful, and a special burner using butane ('Calor gas') was necessary to get the reaction started. From July onwards the underground fire was kept alight, air being pumped down one shaft and a rather low-grade gas being drawn off from another. This gas is quite unsuitable for ordinary domestic purposes, but it could be used to generate electricity by using a gas turbine.

Although this work was of an exploratory and experimental character, it is worth noting that during the first two months of the test some 1·6 tons of coal per day were exploited, and the gases reaching the surface had 67% of the calorific value of this coal. Moreover, the seam on which these experiments were made was not suitable for mining by ordinary methods, owing to the amount of non-carboniferous material it contained and its wetness. Between one-third and two-thirds of all our coal reserves in this country exist in the form of such seams which cannot be economically worked by ordinary mining methods; one square mile of a seam like this contains 3 million tons of coal.

Last autumn, two months after the first experiment just mentioned, attempts were made to use the second, or *percolation* method. This method has the big advantage that it eliminates any need for the making of a gallery in the thickness of the seam, which is often very difficult and always costly. Instead, the natural cracks and crevices in the coal are relied upon to make the necessary connexion between the feet of the two vertical boreholes; the combustion of the coal lying between them gradually enlarges the tiny channels until they are big enough to enable a useful volume of gas to be made. Obviously the practicability of this process depends a great deal on the permeability of the coal measure; and Mr. Masterman (the Ministry of Fuel and Power official in charge of these operations) has hit on a very novel and somewhat surprising method of making sure of the initial underground connexion between the two shafts.

Calculation showed that it should be possible, using highly compressed air, actually to split the coal-bearing seams apart, or to lift the overlying strata away from the coal seam upon which it normally rests. For a depth of 100 ft. below the surface, it was calculated that a pressure of 100 lb. per sq. in. should be sufficient to do this, and so a cold experiment was made on a fresh set of boreholes made at another part of the site. With a pressure of 50 lb. per sq. in. or less very little air leaked from the borehole to its neighbours; at 75 lb., 120 cu. ft. of air per hour passed through to a borehole 33 ft. away; and on raising the pressure to 120 lb. the rate of air-flow shot up to 1200 cu. ft. per hour, showing that a definite raising of the strata must have taken place. When the pressure was raised momentarily to 200 lb. the flow was over 100,000 cu. ft. per hour!

This discovery may have a very important influence on the development of underground gasification, for it clearly makes it possible for a 'percolation' system to be established whatever the natural permeability of the coal may be, and much more quickly than was formerly possible. In the 'hot' experiments at Newman Spinney, following



THE DIFFERENCE BETWEEN THE STREAM METHOD (*a*) OF UNDERGROUND GASIFICATION AND THE PERCOLATION (FILTRATION) METHOD (*b*)

In the Percolation Method boreholes into the coal seam are arranged in concentric rings. In (b), left-hand diagram, the coal has started to burn: air passes down the central pipe, and coal gas is brought up in the annular space around the central pipe. 'Galleries' connecting hole A with holes B_1–B_6 are produced by burning the coal at the bottom of all seven boreholes; the cavities so burnt out in the coal enlarge until eventually they connect up with each other. In the next stage the centre pipe is removed from each shaft and air is pumped down the central borehole; the coal gas is then withdrawn from the boreholes of the first ring.

Burning also proceeds along cracks in the coal seam, and this leads to the interconnexion of the primary cigar-shaped zones—the radii AB_1, AB_2, AB_3, and so on—so that very little coal is left by the time gasification of the first section of the coal-field is stopped. The next section is exploited similarly, by pumping air down the ring of borings and tapping the coal gas from the second. So the field is developed, ring by ring.

on the pressure tests we have just described, the coal was ignited by a butane burner fed with air supplied through a central tube, as shown in the diagram. When the temperature of the gases reached 500° C. the butane was replaced by hydrogen from a cylinder and the top of the borehole closed off so that the pressure rose to 100 lb. per sq. in. and the strata overlying the coal began to lift; the air pumped in, after passing through the combustion zone, flowed through the gaps thus produced, and out of one of the other shafts. In order to accentuate the 'burning through' process (after the hydrogen flame had been shut off) the direction of flow was reversed several times. At the end of three weeks the pressure had fallen to 25 lb. per sq. in. with increasing production of gas, and on the following day it was only 5 lb. A 33-ft. long gasification channel had been established through the coal seam and gas (calorific value 85) was being produced at low pressure loss.

The utilisation of the gas produced by underground gasification is not a simple matter, but it seems fairly clear

that the most likely application will be to a gas turbine coupled to an electric generator. It must be remembered that even gas which will not burn at the end of a pipe in still air may still be a useful fuel for a gas turbine, where high pressure and temperature create conditions which are much more favourable to combustion. (It is even proposed to make use of the return ventilating air from mines in this way, although it is normally regarded as perfectly safe because it does not contain more than 1% of methane. Moreover, the gas turbine, having a very low weight-to-power ratio, could perhaps be moved as the seam became exhausted. Some of the seams suitable for underground gasification contain a high percentage of sulphur, and in the present scarcity of that element it should be possible to recover it from the gas.

On the other hand, the quality of the gas fluctuates greatly. The combustion proceeding in the ground under one's feet is very difficult to control; at one moment the reaction space is too large—causing free oxygen to appear in the gas—and at the next there is a roof fall, causing the gas production suddenly to fall. With the knowledge we are acquiring on this site the control of the process is being improved, but it remains to be seen whether it will ever be possible to obtain a sufficiently uniform product to make it possible to utilise it efficiently.

That Sulphur Shortage

THE SULPHUR SHORTAGE is still the most critical raw material shortage facing this country, but it is good news that industry has now decided to go ahead with the project to build a plant to produce sulphuric acid from anhydrite (calcium sulphate). The cost of erecting and running the plant is being raised by major consumers of sulphuric acid, such as Fisons (the fertiliser firm) and Courtaulds, who use sulphuric acid in rayon manufacture.

One way out of the sulphur crisis is to find new supplies of this vital element; the other is to use our sulphuric acid supplies more economically. This is important for a great deal of sulphuric acid is wasted: industry tends to handle this acid as though it was no more precious than water, an attitude which Britain cannot afford in the present emergency. It looks, too, as though we will have to be unorthodox and give up certain practices which are wasteful of sulphuric acid. We explained in the note "Sulphur before Uranium" (DISCOVERY, Feb. 1951, p. 35) that it is not necessary to use so much sulphuric acid in the fertiliser industry; it is quite feasible to use ammonia as a fertiliser without first converting it into ammonium sulphate. This is done in America, and we must be prepared to follow suit. The fertiliser industry is in fact the biggest single consumer of sulphuric acid in the country. It has doubled its consumption in recent years and now uses well over *one-third* of the total supplies available to British industry. A large part of its consumption—about 470,000 tons—goes to make superphosphates. Any process for making superphosphates which would economise in the use of the acid is important.

Superphosphate is made by the action of sulphuric acid on phosphate rock. The product is a mixture of monocalcium phosphate and calcium sulphate. The increasing problem of sulphur supply has led the Chemical Research Laboratory to examine alternative methods of making phosphate fertilisers. The object of the investigation was either to decrease the amount of sulphuric acid necessary or to eliminate it entirely. One of the important considerations which had to be taken into account was the necessity of developing a method which could use the existing plant designed for the sulphuric acid process without major alteration.

The most attractive possibility was to use nitric acid instead of sulphuric, for nitric acid does not require imported materials for its manufacture. The reaction of nitric acid on phosphate rock is completed in a relatively short time. As well as calcium phosphate, calcium nitrate is formed as a by-product, and calcium nitrate is itself a valuable fertiliser. The disadvantage is that it absorbs moisture very readily. The fertiliser therefore cakes badly in storage and is of no use to the farmer. Removing the nitrate would take too long and in any case would increase the cost too much. Even then some use would have to be found for the nitrate by converting it into some form of fertiliser less sensitive to moisture.

The successful method developed by the Chemical Research Laboratory consists in treating rock phosphate with a mixture of nitric acid and sulphuric acid, in almost the same way as the original process using sulphuric acid alone. The proportion of nitric to sulphuric acid is about 4 to 3. The method is successful because calcium sulphate is formed as well as calcium nitrate. Calcium sulphate is inert and will not pick up any moisture no matter how damp the atmosphere. Since it also has the property of coating the grains of calcium nitrate it protects this also from becoming damp.

The process gives a product which is relatively non-caking and will keep reasonably dry in the normal British climate. Experiments have also been carried out to produce a 'complete' fertiliser by adding potassium chloride, the chief source of potash. A P-N-K fertiliser containing 10% of potash was prepared. This material was more sensitive to moisture, but its laboratory tests were very severe, and it is likely to prove a reasonably good product in practice.

The substitution of sulphuric acid by nitric acid is by no means new in this connexion. Russian investigators studied the idea about 1937. Since then Dutch workers have gone into the details of making a fertiliser by treating phosphate rock with nitric acid. A lecture on the subject was given by Dr. M. H. R. J. Plusje of the Netherlands State Mines in a paper to Britain's Fertiliser Society a few months ago (see *Chemical Trade Journal*, Feb. 23, 1951, p. 440).

At the Netherlands State Mines they are standardising the production of a mixture of 60 parts of ammonium nitrate with 40 parts of dicalcium phosphate, this mixture containing $20{\cdot}5\%$ of N and 20% of citrate-soluble P_2O_5. The ratio between the N and P_2O_5 content could, however, be varied within wide limits and it was also possible to produce a certain amount of water-soluble P_2O_5 in the end product. By the addition of potash salts, such as the chloride or sulphate, to the mash just before granulation, it was also possible to produce complete fertilisers by the process. In this method, which has reached an advanced stage of development, the phosphate rock is dissolved in 50% nitric acid, the reaction leading to the production of calcium nitrate, orthophosphoric acid and water. Part of the calcium nitrate is removed—as calcium nitrate-hydrate

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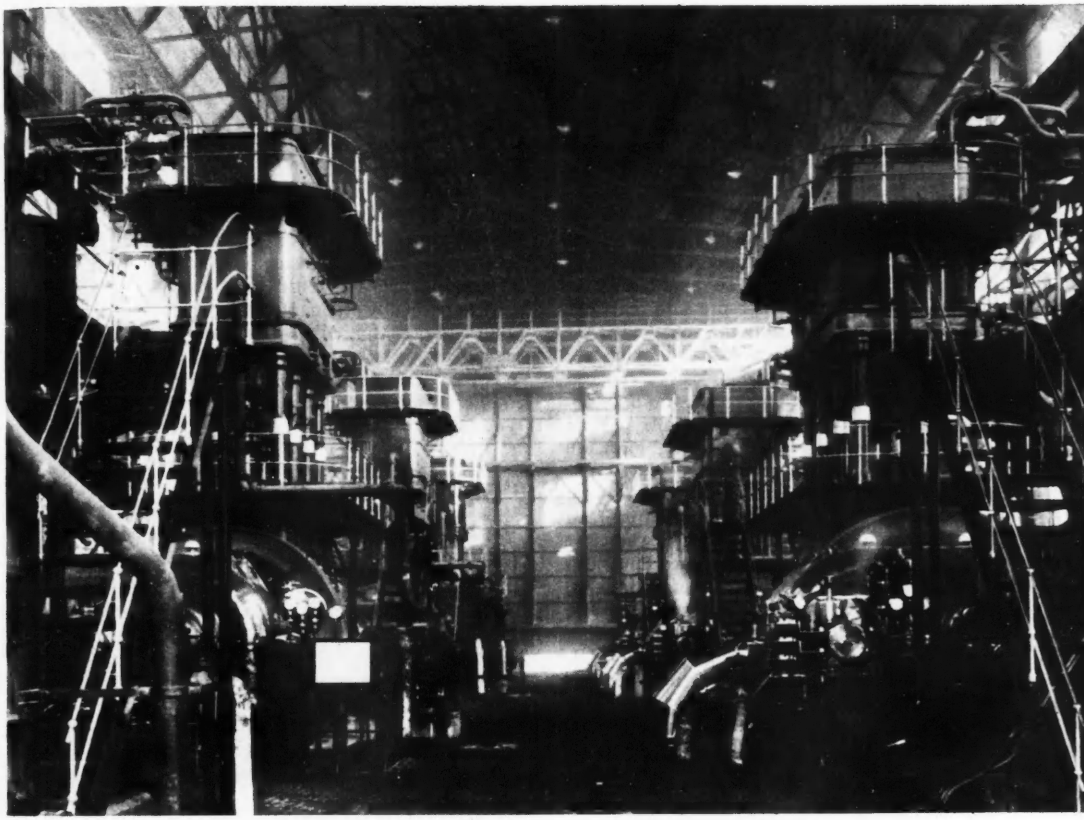

FIG. 1.—Reciprocating gas compressors driven by high-speed steam turbines delivering gas at 250 atmospheres for ammonia synthesis. (*I.C.I. photograph.*)

High-pressure Chemistry

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THERE is very little in our everyday lives to remind us of the large and important place which high-pressure chemistry holds in the world's industries. There are comparatively few places where high-pressure processes have been established and not many people are familiar with the techniques involved. Even for those who are well acquainted with this branch of applied chemistry it is easy to forget how much the food production of the world depends upon it, and how increasingly we use its products in this 'age of plastics'.

The story of the industrial application of high pressures began 40 years ago, when—in 1910–13—the high-pressure synthetic ammonia process was developed by Haber in Germany. This was followed by one for the manufacture of methyl alcohol (methanol) at similar pressures. Both of these processes were operated commercially in England and the U.S.A. as well as in Germany before 1930. By that time, the methanol reaction had also been modified to give a product richer in other alcohols.

The next decade saw a marked expansion in the volume and range of high-pressure processes. Ammonia was in ever-growing demand, both for direct oxidation to nitric acid, and also for use in fertilisers, and there was a growing awareness of the future place of plastics based on formaldehyde (which is made by oxidising methanol). This period saw the commercial application of a number of other high-pressure processes; the production of urea from ammonia and carbon dioxide; the reaction of carbon monoxide with alcohols to produce acetic and propionic acids; the hydrogenation of nitriles to amines and aromatics to alicyclics; and the many-sided developments in the hydrogenation of various coals and oils from petroleum and coal carbonisation sources.

The British contribution in this expansion may be exemplified by the building of the hydrogenation plant for the production of petrol from coal and creosote oils at Billingham, where experience had already been gained in the high-pressure production of ammonia and methanol.

World War II gave great impetus to the expansion of high-pressure industries, especially of ammonia production, and to the development of new processes. An outstanding example is the preparation of the new polymer—called polyethylene. (Polythene is the trade name for this substance.) This material was the result of research in England on the reactions of ethylene at pressures of 2000 atmospheres; its valuable properties as an insulating material contributed much to the success of the radar systems installed by the Allies in the later war years. At the same time advances were being made, mainly in Germany, in the application of other high-pressure reactions involving carbon monoxide, especially the so-called OXO reaction in which hydrogen and carbon monoxide are added to olefines to form aldehydes which can be reduced to alcohols or oxidised to acids. This process and developments of it are destined to play a considerable part in modern organic chemical industry. Other high-pressure reactions now coming into prominence include the hydration of olefines to give alcohols.

This rough outline of the development of commercial processes based on high-pressure chemistry is sufficient to emphasise their industrial importance. They have also had a profound effect on the world events of the last 40 years. The Haber process for synthetic ammonia made Germany independent of outside sources of fixed nitrogen needed for explosives manufacture during World War I, and high-pressure hydrogenation processes supplied over 95% of the aviation fuel used by Germany in World War II. Apart, however, from any war-time associations, these two processes are of considerable significance today, for the first of them is the chief contributor to modern synthetic fertiliser production, and the second may yet prove its value in a world of limited and dwindling petroleum resources.

The large-scale operation of a process at a pressure of some hundreds of atmospheres demands special equipment and techniques. The plant required includes high-pressure vessels, compressors, injectors, pipes and valves and, for the operations of the plant, instruments for measuring, recording and controlling high pressure. When moving from low pressures to the region of, say 300 atmospheres, chemical and engineering principles remain unchanged, but new techniques and designs become necessary and many new problems have to be faced. The work in this field is more costly and, in many ways, more difficult so that it is interesting to inquire into the underlying reasons which make the high-pressure field attractive to the chemist for some processes. For this, it is necessary to go back to some of the fundamentals of physical chemistry opened up during the years 1860–90 by the researches of Guldberg and Waage, Willard Gibbs and van't Hoff.

They can best be approached by considering the well-known principle of mobile equilibrium in the form associated with the names of Le Chatelier and Braun. "If a change occurs in one of the factors, such as temperature or pressure, under which a system is in equilibrium, the system will tend to adjust itself so as to oppose, as far as possible, the effect of that change." This very general principle is not limited to chemical reactions. For example, when ice melts, the total volume of (ice + water) is reduced; hence, when ice is compressed it melts since, by reduction of volume, it tends to offset the increase in pressure. The fact that the freezing point of water falls as pressure is increased is well known, but the magnitude of the effect is not so generally appreciated. At about 2000 atmospheres pressure the freezing point has fallen to —22°C., but at still higher pressures a more dense variety of ice is the stable form, and so the freezing point now rises with increasing pressure, reaching 0° at 6400 atmospheres, 100°C. at about 24,000 atmospheres and 192°C. at 400,000 atmospheres. Other liquids which freeze with reduction in volume show a similar rise in freezing point with pressure; benzene, for example, melts at 100°C. at about 4200 atmospheres—a pressure readily attainable today. This change in freezing point is an example of the physical effects which are comprehended in the principle of mobile equilibrium.

For an example of the principle in the field of chemical equilibria we may take the reversible reaction of ammonia synthesis:

$$\underset{\textit{nitrogen}+\textit{hydrogen}}{N_2+3H_2} \underset{\textbf{Reverse reaction}}{\overset{\textbf{Forward reaction}}{\rightleftharpoons}} \underset{\textit{ammonia}}{2NH_3}$$

The forward reaction occurs with a decrease in the number of molecules in the system and hence with a reduction of volume if the pressure is constant.

The forward reaction also occurs with the evolution of heat.

These two features are the clues to the development of a practical ammonia synthesis process. It can be shown by thermodynamic calculations that the mixture of nitrogen, hydrogen and ammonia in chemical equilibrium at atmospheric pressure and 27°C. contains 98·5% ammonia. But nitrogen and hydrogen cannot be persuaded to combine at this temperature, and, even with the use of catalysts to assist reaction, much higher temperatures are required before the combination takes place. If we apply heat and raise the temperature of the mixture, however, the equilibrium composition according to the above principle will move in such a direction as to oppose the effect of heat, i.e. in a direction associated with absorption of heat, and the equilibrium mixture contains less ammonia. In fact, at 327° there remains only 8·7% ammonia in the mixture. The temperature is still too low for practical purposes and even if the temperature is raised only to 400°C. we find that the ammonia concentration has fallen to 0·46%. Since practical temperatures are for the most part above 400°C., the conversion to ammonia at atmospheric pressure would be very small.

Now, however, we can apply the principle to find the effect of pressure. Since the forward reaction occurs with decrease of volume at constant pressure, the effect of an increase in pressure is to give higher ammonia concentrations at equilibrium. At 450°C. the equilibrium concentration at 1 atmosphere is 0·24%, but at 50 atmospheres it is 9% and at 300 atmospheres 35·5%. If the pressure is raised to 1000 atmospheres the conversion at equilibrium only rises to 69%, so that in practice the lower pressure is usually chosen as a reasonable compromise between degree of conversion and cost of installation and operation.

This typical example brings out the two principal factors which govern the choice of reaction conditions—the

kinetics of the reaction and the position of chemical equilibrium. When the chemist and engineer have decided the pressure and temperature at which a process is to be carried out, they automatically fix the maximum degree of conversion it is possible to attain since nothing can be done to alter the chemical equilibrium in a gas phase reaction at a given temperature and pressure. But there is much that can be done to increase the *rate* at which a reaction proceeds towards that equilibrium. At the heart of almost every high-pressure reaction a catalyst will be found at work, for without catalysts the rate of reaction is usually too slow at the desired temperature. The search is always going on to find better catalysts for existing reactions and for new catalysts for reactions that are otherwise beyond the chemist's reach. The study of catalysis and of reaction kinetics is essential, for all the mechanical aids to high-pressure operation are useless if the rate of reaction is too slow.

There is another very practical aspect of the importance of reaction velocity. High-pressure reaction vessels are expensive, and the maximum amount of useful work must be got out of them. It is not possible to extend the reaction space at short notice to make up for the deficiencies of the catalyst. Then again, catalysts often do not retain their activity indefinitely under working conditions, and it may take some time for a high-pressure reactor, weighing perhaps well over 100 tons, to be opened up for a new charge of catalyst to be put in. So the chemist, seeking to improve the rate of production, must not only try to devise more active catalysts but must also search out the reasons for loss of activity of the catalyst in the high-pressure reactor. Research on the many problems associated with the development of a high-pressure process occupies much more time than the initial proof of the possibility of the reaction, and this research must be carried out in special small-scale pressure equipment.

There are other problems to be faced in high-pressure operation, besides those immediately concerned with the reaction, especially when hydrogen is one of the gases present. One of the early difficulties with ordinary steels was that of hydrogen attack in which the steel is weakened by the removal of carbon. This is generally overcome by the use of alloy steels containing chromium. But a new problem now being faced is known as hydrogen embrittlement. This is due to the penetration of hydrogen at high pressures and temperatures; hydrogen dissolves in solid steel just as carbon dioxide under pressure dissolves in water. But the hydrogen is dissolved in atomic form and when, in the process of diffusion through the metal, it meets a discontinuity or a small hole, the disengaged hydrogen forms molecular hydrogen, and the gas so released in a small cavity can give rise to pressures of thousands of atmospheres and the steel becomes brittle. These effects are only found when high pressures and high temperatures are combined, and so far no really practical answer to the problem has been discovered.

What of the future of high-pressure chemistry? It is safe to say that it will play an increasing part in the chemical industry of the world. It is reported that a number of firms, especially in the U.S.A., are independently undertaking long-range chemical research at pressures over 1000 atmospheres, and even as high as 6000 atmospheres,

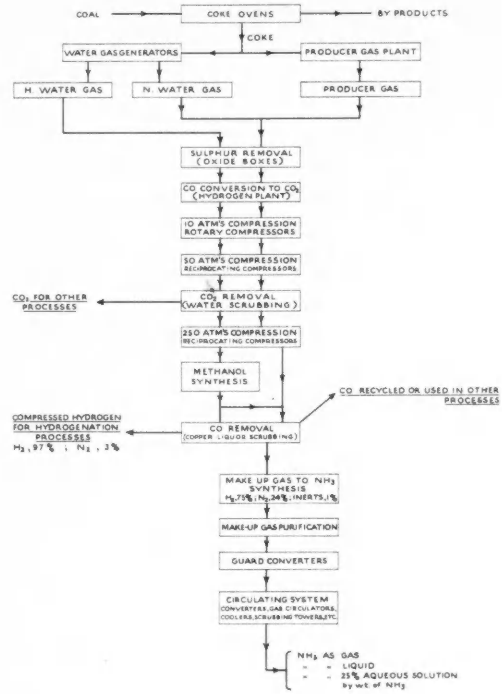
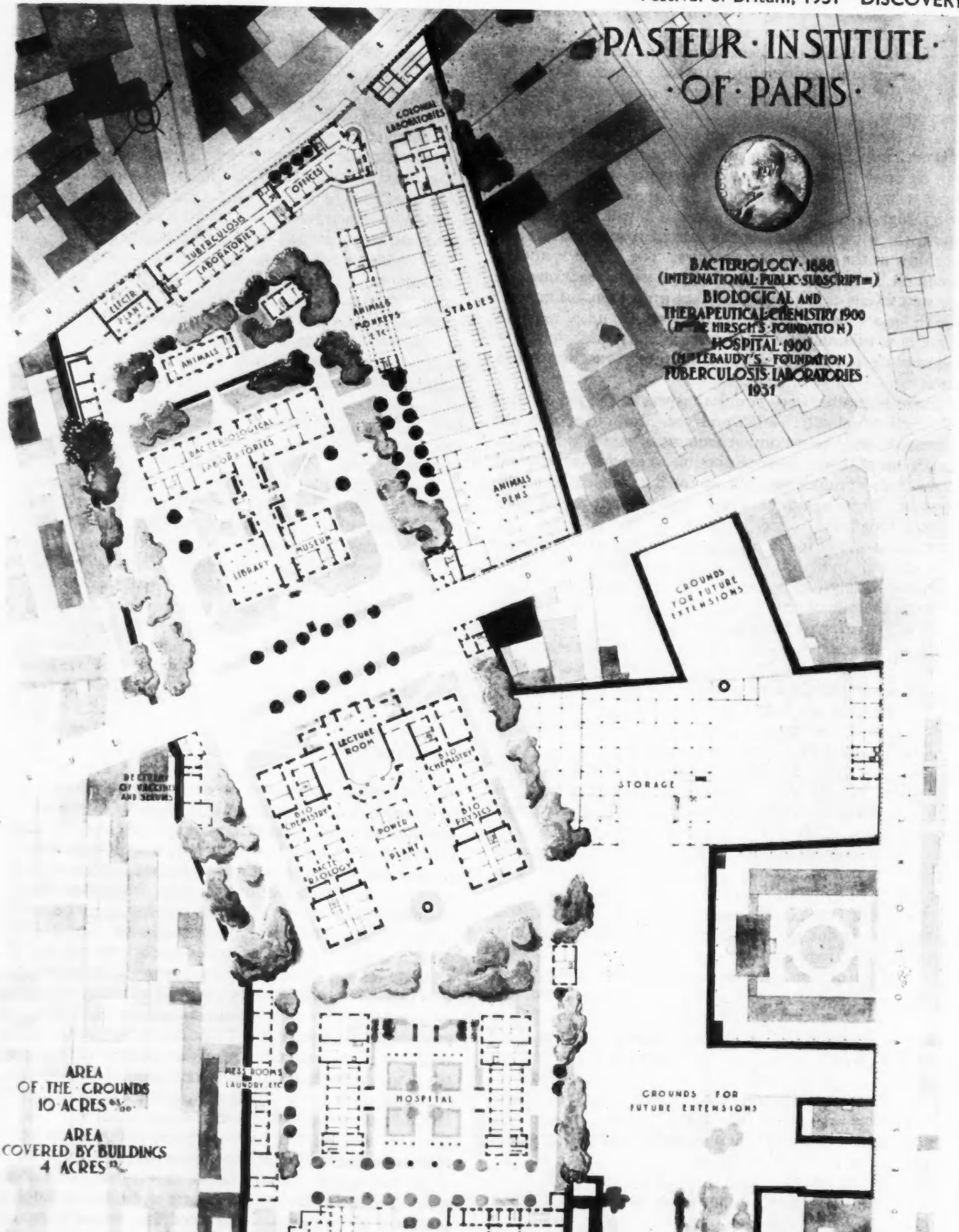


FIG. 2.—The production of ammonia from atmospheric nitrogen.

so that in due course new developments may be expected in this very high pressure region. In addition, research on catalysts may well open the way to the development of new processes in the more usual 300 atmospheres-pressure range. Nor must the role of established processes be forgotten: as was mentioned at the outset, the food production of our present-day hungry world is increasingly dependent upon the high-pressure production of ammonia. The time may also come in some decades when a world, short of petroleum, will turn to high-pressure hydrogenation of coal or tar fractions to supply more and more of its liquid fuel requirements. The recent outcry in the U.S.A. that arose when it was predicted that the end of that country's resources of natural petroleum was in sight gave impetus to the exploration of the economics of high-pressure hydrogenation as the chief alternative for the supply of liquid fuels. Although this scare has passed for a time, the present rate of exhaustion of the world's petroleum resources makes the continuation of such investigations of considerable importance. In the development of this and other high-pressure processes there is abundant scope for ingenuity and chemical insight, and the chemist's reward is to know that he is helping not only to provide for present demands of industry, but also to meet the needs of the future generations.


PASTEUR · INSTITUTE · OF · PARIS ·
BACTERIOLOGY · 1888 (INTERNATIONAL · PUBLIC · SUBSCRIPTION)
BIOLOGICAL AND THERAPEUTICAL CHEMISTRY 1900
HIRSCH'S · FOUNDATION
HOSPITAL · 1900
LEBAUDY'S · FOUNDATION
TUBERCULOSIS · LABORATORIES 1931
COLONIAL LABORATORIES
OFFICES
TUBERCULOSIS LABORATORIES
ELECTR. PLANT
ANIMALS
ANIMALS MONKEYS ETC
STABLES
BACTERIOLOGICAL LABORATORIES
ANIMALS PENS
LIBRARY
MUSEUM
GROUNDS FOR FUTURE EXTENSIONS
LECTURE ROOM
BIO CHEMISTRY
BIO PHYSICS
POWER PLANT
BACTERIOLOGY
STORAGE
MESS ROOMS LAUNDRY ETC
HOSPITAL
CLINIC
GROUNDS FOR FUTURE EXTENSIONS
AREA OF THE GROUNDS 10 ACRES
AREA COVERED BY BUILDINGS 4 ACRES

The Pasteur Institute

H. O. J. COLLIER, Ph.D.

In 1886 the French Académie des Sciences, inspired particularly by Pasteur's discovery of a successful method of inoculation against rabies, opened a subscription list for building an institute for Pasteur.

In November 1888 the President of the Republic opened the Institut Pasteur, built with the subscriptions received. At this time Pasteur wrote:

> *Our Institute will be at the same time a clinic for the treatment of rabies, a centre of research on infectious diseases and a centre of teaching in studies related to microbiology.*
>
> *Cherish carefully the enthusiasm which you have possessed from the first, but give it the inseparable companionship of strict control. Put nothing forward that cannot be proved simply and decisively.*
>
> *Cultivate a critical spirit. Alone, this neither inspires new ideas nor stimulates to great things. But without it, all is chaos. It always has the last word. What I ask of you, and what you will ask in your turn of the disciples whom you will form: is the most difficult thing for an inventor to do.*

Twenty years before, Pasteur had written: "Take an interest in those sacred buildings that are described by the expressive name laboratories, demand that they shall be multiplied. They are the temples of the future."

Louis Pasteur sounds in these pronouncements like one who is founding a new creed or a new church, rather than a scientific institute; his words reflect the fanatical devotion to science which he himself possessed, and with which he somehow imbued the atmosphere of the institute he founded. The visitor feels something of this devotional atmosphere as he is taken into Pasteur's multi-coloured tomb in the cellar of the original building. No doubt Pasteur's way of thought has proved an inspiration to many who work there, for I think I am right in saying that the scientific world has been astonished by the vitality, the powers of multiplication and above all the powers of discovery, which the Institut Pasteur has shown since it was opened.

At its beginning the institute consisted of two buildings joined by a corridor. The smaller building, which faced the street, contained the laboratories and rooms of Pasteur himself and the library. The larger building contained the laboratories housing the various branches of microbiological studies which Pasteur set up—the Anti-rabies Service, directed by Professor Grancher; General Microbiology, under Professor Émile Duclaux; Hygiene in relation to Microbes, under Charles Chamberland; Microbiological Technique and its Applications, under Émile Roux, and Microbial Morphology, under Metchnikoff and Gamaleïa.

The foundation of the Institut Pasteur followed the discovery that infectious diseases are due to invasion of the body by certain species of microbes. Pasteur and his colleagues had played a leading part in establishing this principle. Furthermore they had shown that the body was able to build up resistance against microbial infection, and they also showed how this capacity to resist microbes could be used in various ways to treat or prevent infectious diseases. To quote Pasteur, they learned to make "a means of cure from the agent of sickness and death".

As we have seen, the institute was founded as a centre for treating microbial diseases, and for teaching and research on microbiology. Let us now inquire how far the institute has fulfilled the aims of its founder. In relation to this we may here remark that the first three directors, Pasteur himself, Duclaux and Roux were all chemists by training, who approached medicine through the critical and scientific eyes of those trained primarily in another subject. And these early "Pastoriens" were well aware of the revolutionary part they were playing in the development of medicine. Their attitude is well summed up in Roux's words (written of Duclaux actually): "He judged scientific doctrines by their fecundity without believing them to be final, and he considered the most fruitful periods of science to be those in which dogmas are shaken."

Work on rabies occupied an important part of the early days in the Institut Pasteur. No doubt many readers are familiar with Edelfeldt's painting of Pasteur in his laboratory. In this picture Pasteur is thoughtfully considering a curiously shaped bottle. Inside the bottle a reddish strip is suspended from the top; this small reddish strip is the spinal cord of a rabbit. The bottle, one of Pasteur's own design, is being used to dry the rabies virus which is living in this strip of spinal cord. By the drying method Pasteur had found he could make the virus of rabies harmless to man and that modified virus can be inoculated into a human being with safety to build up in the body a protective power against rabies. Pasteur introduced the practice of vaccinating with the dried virus those who had been bitten by dogs or wolves suspected of being infected with rabies. As a result he was able to reduce the death-rate among sufferers from rabies from as high as 80% to as little as 1·15%.

In 1895 Pasteur died, and Émile Duclaux, who had been his friend and collaborator for many years, took over the directorship. During Duclaux's directorship the Hôpital Pasteur was opened, the existence of which naturally led to an increase in the scope of research on the nature and treatment of infectious diseases.

Duclaux was succeeded in 1904 by Émile Roux, who directed the institute until his death in 1933. During the period which closed with the death of Roux, many famous research workers contributed to the work of the institute. Apart from the heads of departments whom I have already mentioned, there were people like Yersin, Bordet, Gengou, Calmette, Guérin, Haffkine, the brothers Nicolle, the brothers Sergent, Laveran, Mesnil and Levaditi.

Daughter Institutes

Pasteur took a deep interest in tropical diseases. For example, he sent a team led by Roux to investigate an epidemic of cholera; the expedition was to cost the life of one of the scientists—Thuillier who died of cholera. Work on tropical diseases and service to medicine in the French

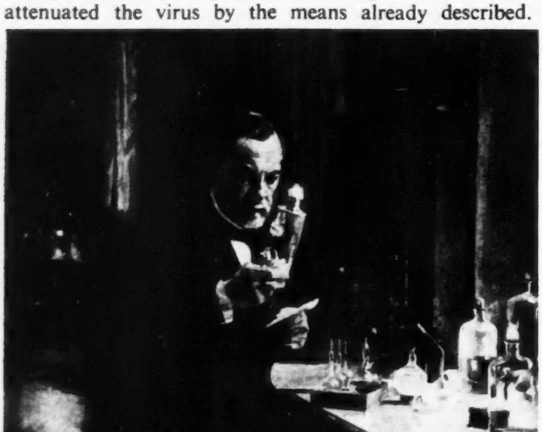
Empire has always been part of the policy of the Institut Pasteur. The establishment of laboratories and institutes all over the world, and especially in French colonies, has been a logical expression of this policy. The aim of these daughter laboratories and institutes has been primarily to serve medicine in their area, by microbiological diagnosis, and by supply of or treatment with sera and vaccines. In addition to this service, many of the directors of these institutes and their colleagues, fired with the spirit of scientific research acquired in the Paris Institute (for Paris appoints the directors of each of the daughter institutes), have carried out research of a high order. As an example we may quote the discovery of the organism causing plague —*Pasteurella pestis*—by Yersin, director of the Pasteur Institute at Nha-Trang in Indochina.

By 1938 there were at least twenty-six of these offshoots of the Institut Pasteur outside France. The majority of these were in the French Empire—in Indochina, Guiana, North Africa, South-west Africa, Réunion and elsewhere. Others, like those in Athens and Teheran, were established in foreign countries by the invitation of the governments concerned. In France itself a daughter Institut Pasteur is situated in Lille, and an offshoot of the institute in the shape of a farm and laboratory producing and investigating sera is working at Garches.

The astonishing power of multiplication which the Institut Pasteur has shown no doubt reflects the value of the work which the daughter institutes carry out in their respective areas.

B.C.G.

The attenuation (or the reduction of the virulence) of an infectious microbe or ultra-microbe was practised by Pasteur on several occasions in preparing vaccines. For example, in preparing his vaccine against rabies, he attenuated the virus by the means already described.



Pasteur in 1887.

A vaccine against tuberculosis came out of the researches of Calmette and Guérin. They began their search for a T.B. vaccine in 1908, and by 1921 they had carried out 271 successive cultures of the tubercle bacillus in a culture medium containing ox bile, and in this process the tubercle bacillus lost its ability to cause tuberculosis when injected into human beings.

Since 1921 this strain of the tubercle bacillus, known as the bacillus of Calmette and Guérin—or B.C.G.—has been used to inoculate millions of children. It is claimed that, if this bacillus is administered in the correct way, the children receiving it show the skin reaction to tuberculin which is characteristic of those infected with the tubercle bacillus, although they do not suffer from the disease. Thereafter they are considerably better able to resist infections of tuberculosis than children who do not show a positive skin reaction to tuberculin. There is still much debate in Britain about the efficacy of B.C.G. vaccine, but on the Continent and in other parts of the world, it is very widely used.

At the Institut Pasteur one whole floor of a large modern tuberculosis building is devoted to production of B.C.G. Here, thousands of tubes of the living bacillus are prepared daily and sent all over Europe. For sending farther afield the bacilli are freeze-dried and they can then be kept in refrigerators in a state of suspended animation for about a year. When it is needed for an inoculation, the appropriate liquid is added and the B.C.G. becomes active once again.

On the top floor of the tuberculosis building at the Institut Pasteur they have a new plant for producing tuberculin. Tuberculin is the substance which enables us, by the skin-test already mentioned, to detect whether or no a person has ever been infected with tuberculosis, and its production is a logical concomitant of the production of the B.C.G.

Therapeutic Chemistry

The present director of the Institut, Professor Trefouël, has for many years worked with great distinction in the Department of Therapeutic Chemistry, now directed by his distinguished wife, Madame Trefouël.

The first director of this department was the famous chemist Fourneau, who was appointed to the post in 1911. Until his death in 1948 Fourneau was one of the recognised world authorities on his subject. Certain of his discoveries served to throw light on the nature of new drugs which had been produced, somewhat empirically, in Germany.

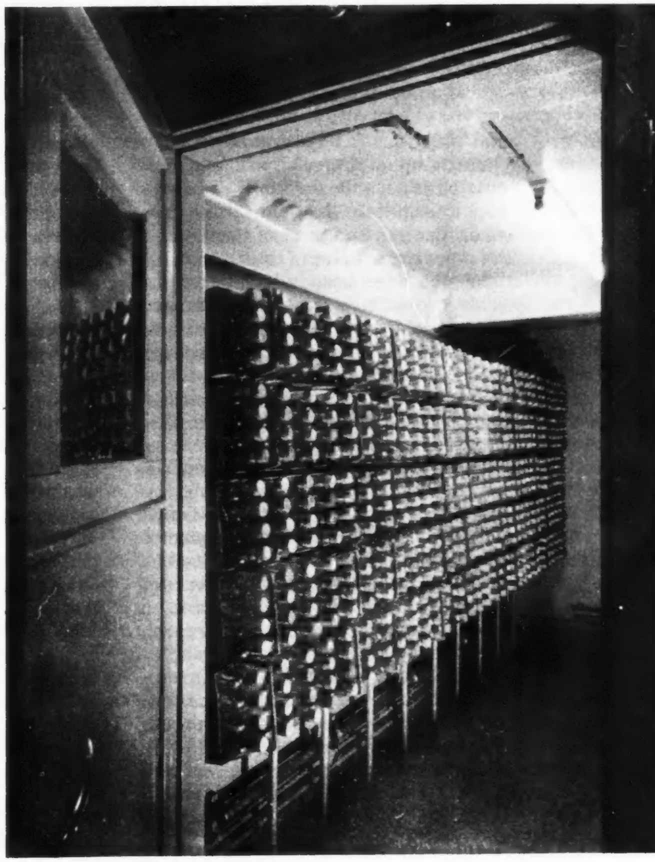
After the First World War, the Germans announced a new drug which would cure sleeping sickness. It was first called Bayer 205 and later Germanin. The Germans kept secret the chemical structure of this life-saving drug. It was the workers of this department of the Pasteur who first discovered and published the correct formula.

Some years later the Germans introduced the well-known drug Prontosil for use against certain serious infections—for example, puerperal fever, still a danger in childbirth.

The scientists at the Institut Pasteur applied themselves to the study of this substance. By a brilliant deduction they were able to show that Prontosil was made up of two parts, one of which was operative and the other inoperative. The operative part was converted by the body into sulphanilamide. Sulphanilamide, as you may know, provided the first

link in the great chain of sulphonamides which have done so much to protect us against many infectious diseases. The logic which lay behind this discovery is most interesting. The Pasteur workers began by making new derivatives of Prontosil. They noticed that if they changed one half of the Prontosil molecule they changed also the activity against microbes; on the other hand changes in the other half of the molecule had no effect on its biological activity. They thus concluded that one half of Prontosil was unimportant and that it was the other part which mattered. They suggested that Prontosil must be broken down within the body, and subsequently deduced that the operative half was converted into sulphanilamide.

A year later the workers in this department showed that a substance called *diaminodiphenyl sulphone* (which was produced as an impurity in the manufacture of sulphanilamide) might also be useful for treating bacterial diseases, an observation which was also made in England by Professor Buttle who published his results at the same time. Derivatives of this substance have been found very useful in treating leprosy. The workers at the Institut Pasteur believe that the sulphones probably act against the leprosy bacillus by being converted within the body back into the parent diaminodiphenyl sulphone, and this compound is now itself being used with success in the treatment of leprosy.



A batch of B.C.G. cultures. (*Photo by René-Jacques.*)

As well as being interested in chemicals which may heal microbial infections, the scientists in this laboratory are keenly interested in useful drugs of other types. Their work started from the accidental observation that some of the compounds they had made to test against malaria had the effect of neutralising the hormone adrenalin. This led them to explore chemicals which might antagonise other naturally produced substances, like histamine. Dr. Bovet (now a professor in Rome) has perhaps been the leading spirit in this work, and he has played a great part in developing the anti-histamine drugs and—incidentally—the curarising drugs. But let me explain these terms. Our bodies sometimes liberate histamine in response to some shock or injury. When histamine is liberated in excess it causes unpleasant symptoms, for example, rashes, hay-fever and asthma. The scientists at the Institut Pasteur showed that certain chemicals could be made which would neutralise the effect of histamine.

Now let us turn to the curarising drugs. It is known that the Central American arrow-poison known as curare relaxes muscles by preventing messages in a nerve from making contact with the muscle. In reality, the curare antagonises the substance responsible for transmitting the message between nerve and muscle. The various chemicals which make up curare are themselves too complex for chemists to synthesise. Since the drug is costly, the discovery of the Pasteur workers that they could make substances which would imitate the action of curare was very important. The most useful of the substances they studied, called Flaxedil, is modelled on the native arrow-poison, but it can be made fairly easily in the laboratory. This drug is useful to surgeons because it can be used to relax the muscles of people under anaesthetics. This relaxation enables the surgeon to do his work more easily and helps to protect the patient from excessive doses of anaesthetic.

As we have seen, the Institut today is carrying on extremely important work in production and in research. Its staff numbers over 1000, and its budget is roughly equivalent to a million pounds a year. The Institut Pasteur is extremely proud of its tradition, for it has played an outstanding part in the conquest of infectious disease which we have witnessed during the present century. Without doubt there is a great future in microbiology—the field of antibiotics alone indicates how great this is. And there is no doubt that the Institut Pasteur will continue to play a worthy part in the development of the subject it has already promoted so effectively.

The Bower Birds of Australia

A. J. MARSHALL, B.Sc., D.Phil.

BOWER BIRDS all build 'playgrounds'. The true bower birds build a bower or 'theatre' quite distinct from their nest. Three species of bower birds paint the walls of their bowers and one makes a tool to help it do this. All species have remarkable displays or 'dances'; and most of them mimic brilliantly the calls of other birds. Some of them, especially the males, are among the most beautiful of birds: the striking blue eyes of the satin bower bird, the regal plumage of the regent and golden bower birds, the rose-lilac crests of the genus *Chlamydera* would make their owners notable without their other attributes. All in all, the bower birds of Australia and nearby islands are the most remarkable group of birds known, and this does not exclude their close relatives, the birds of paradise.

And because they are so extraordinary, a whole 'popular' literature has recently sprung up about them. Much of it is nonsense. The nineteenth-century naturalists, Gould and Darwin, knew little about bower birds, but it seemed to them that, however singular their bowers and displays may be, they were still primarily a courtship device of some unusual sort. But during the last thirty years there has arisen a school of Australian naturalists who, though admitting that sexuality may play some part in display and bower construction, nevertheless assert that it is of only subsidiary importance and that the primary motivation is 'recreational'. They say that the birds undergo these special activities essentially because they 'like' to do so. With this 'recreational' theory there have been advanced many claims that bower birds possess considerable powers of intelligence. One writer in a scientific periodical has credited the satin bower bird with the capacity for deductive reasoning. Apart from descriptive matter, little of what has been written about bower birds will stand up to critical inquiry.

The family is divided into two groups—catbirds and bower birds proper. Three catbirds occur on the Australian mainland and these are all confined to the dense tropical and sub-tropical rain-forests or jungles along the eastern seaboard. The spotted catbird got its name from its voice, which does indeed sound rather like that of a domestic cat. Two catbirds, the green and spotted species, are predominantly greenish in coloration and blend cryptically with the jungle foliage in which the birds live. These two do not build display grounds. The third catbird, however, has diverged sharply from the common stock. It has taken to the shadowy sub-canopy: it has become mottled brown in colour and it has become a display ground builder and one of the most accomplished vocal mimics in a country that is notable for its mocking birds. Further, this brown fruit-eating catbird has developed a 'toothed' beak with which it severs the petioles of leaves that it uses for the decoration of its display ground.

Scenopœetes dentirostris—the tooth-billed 'bower bird' or *stagemaker* (as its Greek generic name has it) clears a space six or eight feet in diameter on the debris-strewn floor of the tropical jungle or 'big scrub' of a restricted area of North Queensland. The stage is kept scrupulously clear of fallen leaves or shoots from underground stems and its bare dark earth is decorated with between 20 and 100 fresh leaves laboriously 'sawn' (with toothed beak) off trees and shrubs in the vicinity. Only certain species of leaves are used. These wither in the tropical heat and are replaced early each morning. The leaves are generally arranged with paler under-surfaces uppermost and this creates a more striking pattern against the dark jungle floor. Often a bird will spend a considerable period sawing away with its 'toothed' beak whereas, if it only knew how, a simple sharp downward jerk would free the leaf in a fraction of a second. We have, of course, no idea of the antiquity of the leaf-sawing habit or of the beak-form that goes with it, but it is clear that if the bird had been able to learn how to perform one simple movement the 'teeth' would not have had survival value. So much for intelligence in *Scenopœetes*.

From a special perch, or 'singing stick' some few feet above its leaf-strewn display ground, *Scenopœetes* sends out an almost continuous babble of song into the thick tangling jungle around. Visibility is usually limited to fifty feet and often much less. If one stands at almost any point in the jungle where the birds live one can hear two or three and often more stagemakers calling loudly in rivalry and, perhaps, in emulation. It would seem that the babble of noise (which continues almost unceasingly for hours) is a device that advertises the caller's presence and the whereabouts of the focal point of his territory, the stage, to every male rival as well as to all potential mates in the area. More precise functions of the leafy stage are as yet unknown, for apart from the early morning visits to change the leaves, birds have rarely been seen to descend from their singing sticks above the stages. One brief experiment gives us a possible clue to its function: a dead bird (the sexes are identical) was placed on a branch not far from a display ground whereupon the owner immediately dropped down to the edge of the leaf-display, and, peering up at the dead bird all the while, called in a peculiar way as though in invitation. It is possible, then, that the stage of *Scenopœetes* is a courting place to which the opposite sex ultimately is attracted by the prolonged song that echoes through the scrub. At the time of year that the female builds and lays, the stages are allowed to fall into disrepair and the song ceases. Leaves wither and curl, but are not replaced. The ovulation of the female and the appearance of the young occurs at the beginning of the monsoon which seems to bring with it an abundance of insect food and the contained amino-acids that are essential for the development of the young. For, although the adults eat mostly fruit, the young 'bower birds' are fed on beetles and other insects. Thus we seem to have a very pretty example of how the sexual cycle of an animal is geared to the environment so that the young will be produced at the time of year most propitious for their survival.

In our search for a precise function of the display ground, we are on comparatively safe ground in the case of one of the true bower birds—the glistening, blue-eyed

satin bird (*Ptilonorhynchus violaceus*). This is a bird whose range extends down from the tropical jungles of northern Queensland to the open forest and bracken of southern Victoria. The mature male satin bower birds have a lustrous blue-black plumage. The females and young males are of a cryptic green-grey coloration, but they have the same wonderful eyes as the males. About mid-winter the old blue males leave the mixed fruit-feeding flocks and return to their individual territories and rebuild their bowers. Each bower is a double-walled structure of twigs, which sometimes meet as an arch overhead and almost always point across the path of the sun. On the foreground of the bower the male accumulates an assortment of coloured articles gathered in the forest. Most of these bower decorations approximately match the colours, especially the eyes and beak, of the female which the displaying male soon attracts to the vicinity of the bower. Prior to white settlement the bowers were apparently decorated chiefly with blue parrots' feathers, freshly plucked bluebells and other bright blue or pale lemon-yellow flowers. Brown snail-shells and grey fungi were, and still are, used. But nowadays all manner of articles of civilised manufacture are found on display grounds. Bus tickets, hair ribbons lost by children, bits of glass bottles and any other object is collected and taken to the bower if it fits in with the traditional colour scheme of the species. Country housewives complain that during the spring and early summer months satin birds will boldly enter their laundries and steal washing blue-bags. Some farmers have been known to shoot the bold blue males, not only because they raid the

The male Satin Bower Bird at its bower. (*Photo by A. J. Marshall.*)

orchards, but because it is impossible to keep delphiniums or petunias intact in the homestead gardens. An old blue bird has been known to rip off and carry away spikes of delphiniums longer than himself on one Queensland farm.

The male uses his decorations in the course of his display to the female. She is attracted to the bower and takes up a position close behind it. Keeping himself in view of the watching female, the male seizes a blue feather or a snail-shell in his beak and, uttering an extraordinary 'mechanical-sounding' whirring 'song', displays to his mate with tremendous emphasis and jerky, intermittent movement. The sun reflects from his plumage, creating an almost magpie effect in photographs at certain angles. There is a threefold effect of colour, noise and movement which the female regards impassively from behind the bower. Sometimes she moves away and then the male tries to recall her. If she refuses to return he usually temporarily leaves his display ground and follows her through the forest.

The satin bird paints or plasters the inner walls of its bower. In the Sydney area the favourite paint is a suspension of chewed charcoal (from logs burnt in bush fires) in saliva. The male chews into shape a fragment of bark and holds it in his beak-tips as a kind of 'stopper' and, with the charcoal-and-saliva paint oozing from between the mandibles, plasters or paints the walls with black fluid. This dries into a black powder which does not remain very long in position. The performance, which has been filmed, is repeated daily at the height of the display season. In more northern areas the favourite plaster seems to be fruit-pulp.

Meanwhile, tremendous jealousy and rivalry exists between the males of adjacent territories. If one blue bird is momentarily absent feeding or pursuing the female, a blue neighbour, if he is young and aggressive enough, creeps stealthily along the ground into his territory and works swiftly to wreck the bower, its focal point. This, too, has been photographed. After working at top pressure to tear the bower to pieces, the neighbour snatches up a brightly coloured object and carries it off to his own display ground. If surprised, he never stays to dispute. In his restricted territory each blue male is king, plagued only by hit-and-run raids on his property. But the younger green males which, though sexually mature, have not yet developed the bright display and threat plumage, appear to have no redress when the older birds raid their bowers and steal their display things. The green males collect blue objects—but the blue birds rarely allow them to keep them for long. This was proven by charting the movement of diamond-scratched fragments of blue glass from bower to bower through the forest.

If a blue male is killed at the bower, the female remains in the vicinity and she, and the bower, appear to be taken over as a 'going concern' by one of the apparently unattached green males of the area. These achieve full spermatogenesis and probably sometimes breed. If the female is removed from the bower the blue owner soon attracts a second female and displays before her. The bower and its decorations, as well as the fantastic attitudinising and vocal accompaniment, seem primarily a device whereby the hen's interest is retained until male and female reproductive rhythms are synchronised and events in the environment make for a successful mating.

Display begins at about the winter solstice (varying

between individuals) and continues for about three months, when, in late September or in October, the female goes off to build her nest a hundred yards or so from the bower. We do not know what *releaser* operates to transfer the male's physical attention from the ornaments to the female, but it is certain that mating and ovulation do not occur until the time when the great summer harvest of flying insects—beetles, termites, moths, cicadas—appears in the forest. Although the satin bird is largely frugivorous it, like most, if not all other birds, must have protein food in order to bring its young to maturity. It has been shown experimentally that although bower birds pursue avidly flying insects, they have not the intelligence to scratch aside leaves when insects take refuge beneath them. It is suggested then that although it is advantageous for the species to take up territory early, it is impossible for it to reproduce efficiently (i.e. rear its young) before summer and its harvest of flying insects. We do not know what starts its sexual cycle off about mid-winter nor precisely what causes the female to distract, several months later, the male's direct attention to her from the display things with which he has danced. But, in the long period between the initial and final stimuli, there has been developed all of the aesthetic or other manifestations such as bower-building, colour selection, dancing, vocalisation, painting, regularised thefts, bower-wrecking, and so on. All of these phenomena occur during the waxing of the male gonad. Gonadectomy inhibits them; testosterone dosage reinstates them.

After the female goes away to build her nest the male continues with his display taking no part in incubation or feeding of the young. When the young appear the bower is allowed to fall into disrepair and all the families of the area join up into great feeding flocks which range widely through the forest in search of fruit. After the post-nuptial testis collapse and the development of the new generation of secretory Leydig cells in the testis interstitium, a series of unusually sunny days will send some of the males back temporarily to their territories where they will engage in spasmodic bower-building and display. It is this occasional out-of-season dancing that has caused many people to declare the display of bower birds to be essentially 'recreational' and almost entirely unrelated to the sexual rhythm.

The bower birds of the dry northern and inland parts of the continent belong to the genus *Chlamydera*, the best-known of which is the spotted bower bird (*C. maculata*). Comparatively drab in general coloration, the mature birds develop a mantle of most lovely and unusual rose-lilac. The male spotted bower bird builds its double-walled bower of grass and fine twigs in the shade of low-hung branches in the sunny open inland scrubs and to it brings the white-bleached carapaces of freshwater crabs, mussel-shells, emu eggs, and often literally a bushel or two of whitened bones. Green berries, seed-pods and conifer cones are also used as decorations. With the advent of white men, this bower bird has been able to add green glass, bits of metal such as wire, shining cartridge cases, fragments of tin, lead, nails, screws, buttons, and even lost silver coins and the odd diamond ring. One writer reports that spotted bower birds carried off to their bowers a quantity of fencing

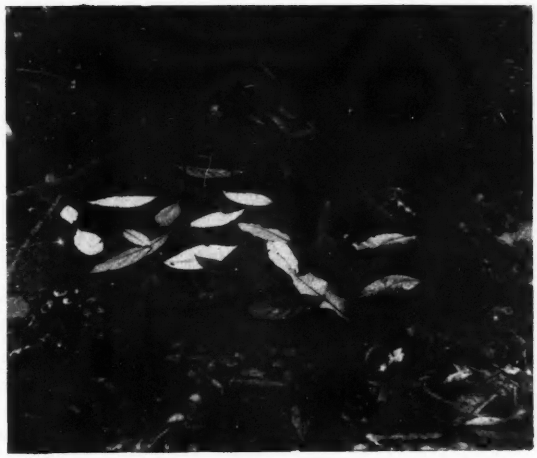
Female (*above*) and male of Satin Bower Bird (*Ptilonorhynchus violaceus*). About one-third natural size. (*From Tom Ireland's, "Birds of Paradise and Bower Birds." Georgian House, Melbourne and Phoenix House, London.*)

staples left along a line of newly sunken post-holes. The veteran collector Jackson says that around his camp "anything bright had to be kept in a box away from the eyes of these birds". There is another account of a glass eye (colour unfortunately not stated!) being stolen from a camp and yet another story of a pepper-tin that had often to be retrieved from a bower at meal-times.

The coloured crest of the spotted bower bird is erectile and iridiscent in the strong inland sunshine. As the male displays he contrives to keep his crest in view of the watching female, who, rather like the female satin bird, watches impassively from behind or inside the bower. Again like the satin bird, the male not infrequently displays by himself at the bower—another reason why most bird-watchers believe that the display is largely 'recreational' and not devoted to any utilitarian, sexual end. However, a few years ago one bird photographer, J. S. P. Ramsay, observed copulation at the spotted bower bird's display ground after a prolonged and violent display. Again, a histochemical investigation of the spotted bower bird's gonads that has just concluded shows that the seasonal waxing of the reproductive organs runs hand in hand with the display cycle as occurs also in the tooth-billed and satin bower birds.

There now seems little doubt that the male's energetic display with his changing choice of display object in the accumulation of bower ornaments is primarily a device to attract and to hold the attention of the female and to help effect synchronisation of the internal reproductive physiology of the pair until the environment is seasonally 'right' for successful reproduction. When this happens, some as yet unknown environmental stimulus (such as, perhaps, the appearance of specialised food for the young) causes the female to exhibit some form of behaviour that will transfer to her the physical attention of the male. In times of very severe drought spotted bower birds sometimes do not breed at all.

In normal seasons this species too takes up territory and builds its bower early—about July and August—and yet the female does not usually ovulate until October, November or even closer to the height of summer with its probable greater productivity of animal food on which the young will be fed. During the long intervening period, when the male gonad is maturing and when the sex hormones are being liberated into the blood-stream, all the excitable display, the gathering of reflecting and other objects, as well as bower-painting (with finely divided grass and saliva) occur. It seems probable that this prolonged



The display ground or stage of bower bird, decorated with leaves. (*Photo by S. W. Jackson.*)

period of sexual activity (with sublimation of sorts, for mating is delayed) has made possible the development of the varied display phenomena in the three species considered above. In the true bower birds, the manifold male activities at the bower have in turn the valuable function (while retaining the female's interest) of diverting the male's physical activities until some as yet undetermined environmental stimuli, operating through the central nervous system, cause her to behave in a way that will allow copulation.

We can at present only wonder at the internal mechanism which has allowed the evolution, and the incorporation within the central nervous system, of the inherent behaviour patterns, described above, which are ready in the individual to be called into operation by the perception of stimuli from the environment and by the liberation of sex hormones. As yet we have no evidence whatever that any bower bird is more *intelligent* than any other crow-like bird. And there is unassailable evidence that, far from being merely recreational, the display phenomena of bower birds are essentially governed by the state of their sex organs and are an integral part of the breeding cycle.

THE PROGRESS OF SCIENCE*—continued from p. 138*

—by crystallisation after cooling the solution, the process being so adjusted that the mother liquor contains equimolecular amounts of calcium nitrate and orthophosphoric acid. This mother liquor is neutralised with ammonia, careful control of the pH being necessary to make sure that the end product contains no calcium nitrate which would render the final product very hygroscopic. After neutralisation the mixture is concentrated, granulated, dried and cooled in the usual manner.

For the production of a phosphatic fertiliser consisting essentially of monocalcium phosphate the State Mines have worked out a cyclic process in which, after the acidification of the phosphate rock with nitric acid the solid monocalcium phosphate is separated. To the filtrate there is added more nitric acid and, after cooling, calcium nitrate-hydrate is crystallised out and removed. The temperature of the mother liquor from this stage is then raised and the cycle outlined above repeated.

SCIENCE IN THE FESTIVAL

SCIENCE THE ENDLESS FRONTIER fairly expresses the dominant theme of the Festival of Britain; exhibit after exhibit puts across the *motif* that the scientist has taken over the job of the explorer, that science is an adventure.

As with all good exhibitions, it is not possible to do justice to the Festival in words: for this reason we publish in our colour supplement an artist's impressions of some of the many striking exhibits of scientific interest, which will provide our readers with a permanent souvenir of the Festival.

In addition to the Science Exhibition at South Kensington, there are many scientific exhibits in the South Bank exhibition, the centre of which is the Dome of Discovery. (The architectural details of the Dome were described recently in DISCOVERY: March 1951.) The aluminium dome, the largest of its kind in the world, spans a remarkable range of displays which tell the story of Britain's pre-eminence in discovery and exploration. The scientists, such as Newton and Darwin, Faraday and Rutherford, are portrayed as the modern counterparts of Captain Cook and Livingstone. British enterprise in the development of overseas territories is another *motif* of the exhibits in the Dome.

A clever piece of presentation is the section called "Minerals of the Island", which is housed in a building shaped like a truncated pyramid. Inside, the impression is created that one is standing at the bottom of a deep mine shaft, an effect achieved by a cunningly contrived perspective.

Next one comes to the "Power and Production" pavilion, which takes the story from raw materials to finished products. It demonstrates the harnessing of power, the processing and uses of metals, the structure of British industry and the role of research, design and management in modern industry. Of outstanding interest are the textiles machines and the offset litho printing press, all of which are working.

The design of the "Sea and Ships" pavilion derived its inspiration from the fact that Britain builds more ships for a great variety of purposes than any other nation. The story of British ships is a vast one, and one finds it overflowing from this building into the "Transport and Communications" pavilion, while oceanographical science finds its logical place in the Dome of Discovery.

"Transport and Communications" is concerned with transport by sea, air, road and rail. The sea story goes back to the coming of the steam boat, the *Britannia* of 1840 and the famous *Great Eastern* of 1858. Marine navigation is well described, and among the modern scientific aids on view is a ship's radar display unit; the picture on the radar screen changes every few seconds to simulate what would be seen during a voyage from London to Antwerp. The evolution of aeroplanes and aero-engines is shown in historical sequence. Included in this display is Whittle's first gas-turbine engine, and also two modern turbo-jet and two turbo-prop engines. The road-transport section has a good sequence showing the birth of a new type of car, from the birth of the idea up to the production of a prototype model. Two outstanding features in this section are the actual test model of the first gas-turbine car and a scale model, 5 ft. in length, showing how revolutionary changes in car-body design may result from new principles of propulsion and transmission: the design of the latter is based not on fashion but on purely functional requirements and represents a serious projection into the future; not a stunt. The development of roads, from the days of the Romans till the present day, is also covered. A section on bridges includes a 15-ft. scale model of the new Severn Bridge which underwent tests at National Physical Laboratory.

The rail-transport section provides a potted history of railway development. The first exhibit here is the *Agenoria* locomotive, built in 1829 by the Stourbridge firm of Foster, Rastrick and Co. This was one of four sister engines built by the firm, and the only one to remain in Britain. The other three (the *Delaware*, *Hudson* and *Stourbridge Lion*) were exported to America. (The last-named engine was put in steam in 1829—before the *Rocket* competed in the famous Rainhill trials.)

Modern engines on show include a 330-h.p. diesel-mechanical locomotive, a 660-h.p. diesel-electric model, and a W.G. class locomotive for the Indian Government Railways. Another display is devoted to railway research.

Communications and navigational aids developed parallel to transport services, and are dealt with in the same pavilion. Britain's telephone system and the radio network provide two outstanding displays, while the television section includes a working TV camera using the 625-lines system. There is a very fine set of exhibits demonstrating the development and uses of radar.

A high-definition radar installation, similar to those used for the supervision of harbours and ferries, can be seen in operation. The 12-ft. aerial for this equipment is mounted a hundred feet up, on a mast outside the building, to obtain signals from a stretch of the River Thames between Lambeth and Blackfriars. These signals are displayed in the form of a radar map on a 15-in. cathode-ray tube, mounted above eye-level so that it may be seen by as many onlookers as possible. River traffic visible on the screen includes the Festival launches plying between Battersea Park and the South Bank.

Two pavilions are devoted to "The Land of Britain" and the "Country" respectively. The first gives a vivid impression of how the British Isles were formed and of the origins of their natural wealth and landscape. The "Country" pavilion has displays showing how the wild life varies from one part of Britain to another, the interdependence of plants and animals, and how man has changed the landscape. This section leads on to the next which is concerned with rural life and agriculture. Full emphasis is given to the contribution of science and mechanisation to British farming. Both livestock and live crops are being shown, and these will be changed as the season advances. A final section deals with forestry.

The Exhibition of Science, which is housed in the new wing of the Science Museum at South Kensington, is devoted to pure science. It aims—very ambitiously and with a brilliance of display technique that is bound to revolutionise the visual presentation of scientific information—to answer two fundamental questions: *What is matter?* and *What is life?* No one who visits this exhibition is ever likely to forget the 'scaling sequence', which starts with a familiar object—the graphite of a lead pencil—and shows the structures that become visible as it is magnified 10 times, 10,000 times, then 100 million times, until finally we see the wave-mechanics model of the graphite atom such as would be visible at a magnification of 10,000 million times.

The principles of a calculating machine are demonstrated by a machine—"Nimrod"—which is designed to play the old match-game called Nim. Visitors are invited to try their skill against this machine, with some slight prospect that they might even win.

A 'stop-press' section highlights some of the latest scientific advances, as for instance in the realm of cosmic-ray research.

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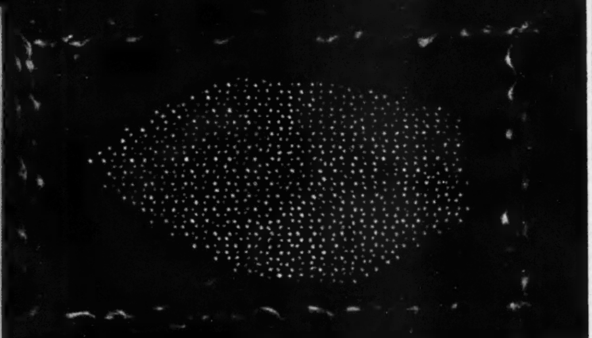
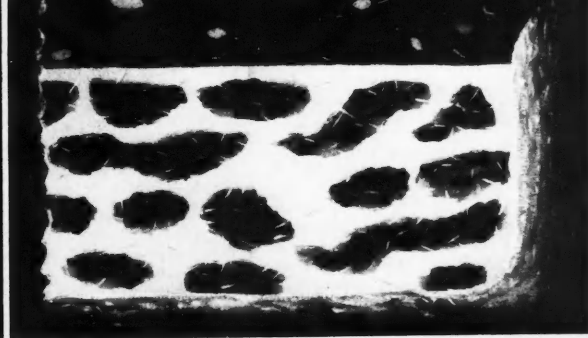
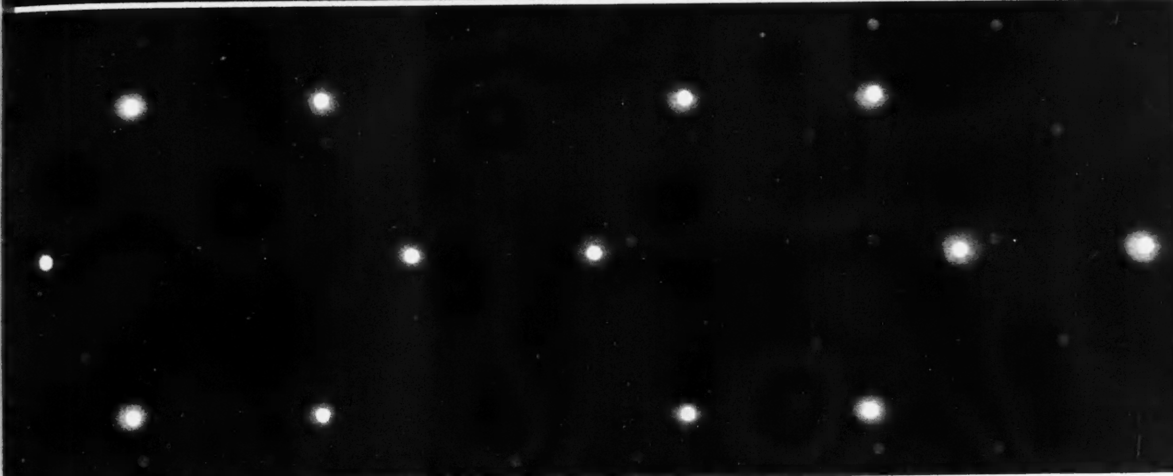
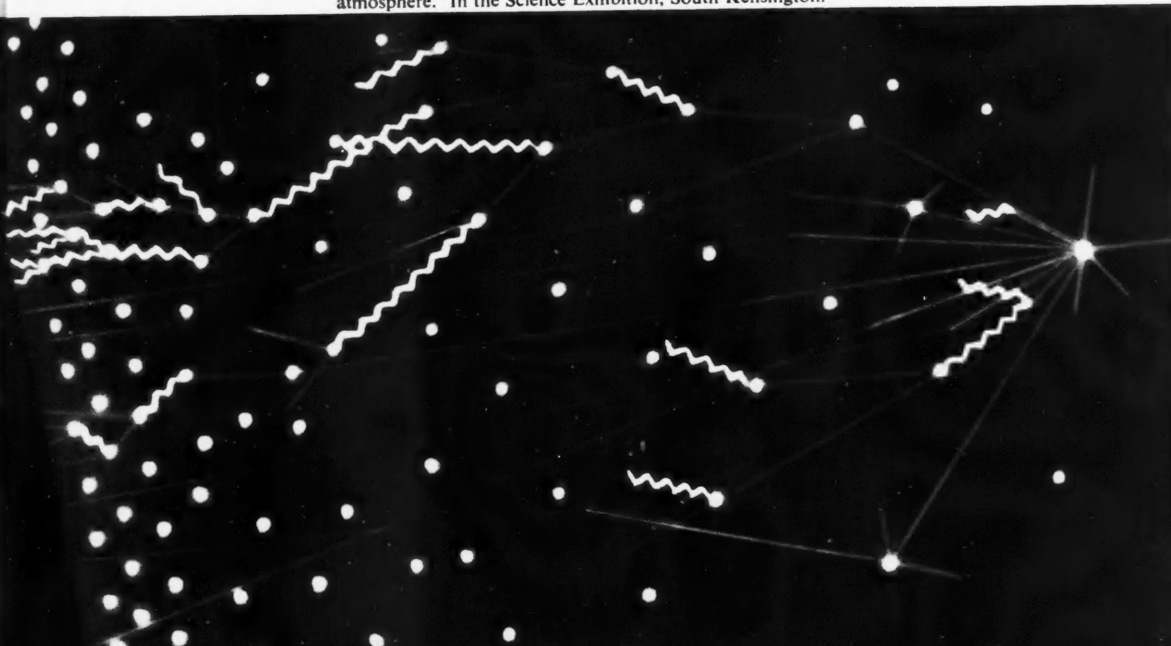


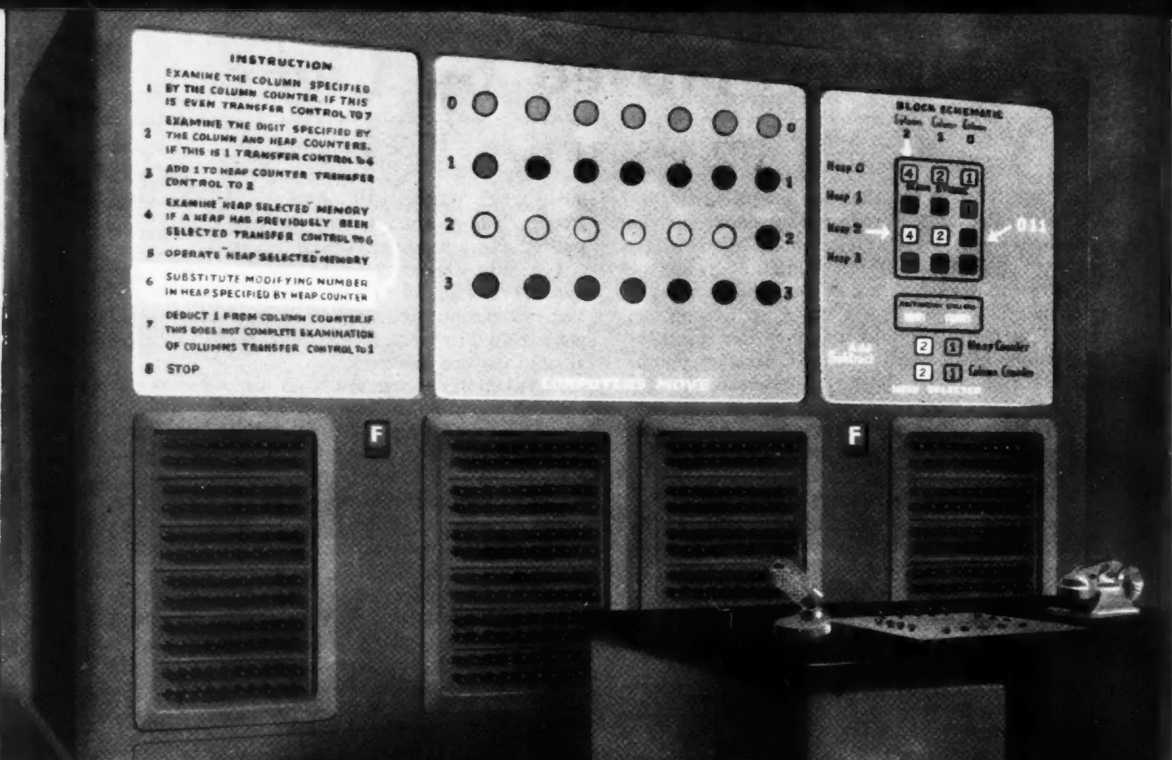




(*Top*)—WHAT MATTER IS. A pencil lead magnified 10^4, 10^8 and 10^{10} times. 10^4—Tip of lead, leaving track of graphite particles on paper. 10^8—Crystal structure of graphite flake. 10^{10}—Wave-mechanics representation of graphite crystal. (*Bottom*)—A COSMIC RAY SHOWER in the atmosphere. In the Science Exhibition, South Kensington.



A COAL MEASURE FOREST
South Bank Exhibition



(*Top*)—NIMROD, the calculating machine designed to play Nim. In the Science Exhibition, South Kensington. (*Bottom*)—OCEANOGRAPHY, part of a mural depicting research ship *Discovery II*. In the Dome of Discovery.

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Matter Moved by Light

DR. GABRIELE RABEL

MORE than twenty years ago, the Viennese physicist, Professor Felix Ehrenhaft, discovered a phenomenon which he called photophoresis. When a concentrated beam of light falls on very tiny particles, of either liquid or metal, the particles are set in motion. Some of the particles move in the direction of the light; others travel in the opposite direction. Ehrenhaft described the first movement as *positive* photophoresis, the second as *negative* photophoresis. The motion of the particles is reversed when the direction of the light is reversed.

Ehrenhaft claims that absorption of light by the particles cannot have a decisive part in the process as the effect is the same whether they are black (e.g., graphite) or reflecting (e.g., silver) or transparent (e.g., transparent plastic material). He also claims that the phenomenon occurs in all gases (it is particularly striking in argon) and even in liquids. Furthermore it occurs at all pressures from as much as thirty atmospheres down to a vacuum of a millionth of a millimetre of mercury.

Physicists know that the pressure of light can propel small material particles, but this 'negative' movement against the incoming light is puzzling. It has been suggested that the movements of heated gas molecules in the surroundings may be responsible for it and this is the view of M. Amié Cotton who presented Ehrenhaft's papers to the Academy of Sciences in Paris. Cotton watched experiments on photophoresis which were undertaken by M. Tauzin and he is convinced that the phenomenon is most obvious at a pressure of about 10 millimetres of mercury and disappears completely at very low pressures. Ehrenhaft, on the contrary, insists that photophoresis does not depend on any action of gas molecules and that it occurs in a very high vacuum and when the substance is thoroughly degassed.

The discussion is still being carried on in the *Comptes Rendus*. In April 1950, Ouang-te-Tchao published experiments undertaken with a different method and demonstrating photophoresis at an extremely low air pressure, but in October 1950, Thibaud declared that his own experiments confirm Cotton's and Tauzin's view. Time will show who is right.

Even more striking is a phenomenon which Ehrenhaft and his assistant Dr. Reeger discovered more recently, and which is illustrated in the pictures on p. 152. The experiments require only a very simple apparatus. Take a spherical glass bottle (Fig. 6), introduce into it a handful of dust—for example pure, fine, dry graphite powder, connect the opening of the bottle with an air pump, evacuate the vessel to a pressure of 10 to 2 millimetres of mercury, give the powder a shake so that it is about evenly distributed, and throw upon it a concentrated beam of light in such a way that the focus of the rays is approximately in the centre of the container. When this is done many of the graphite particles fall to the ground, but a few of them begin to revolve around the light beam in a plane which is always strictly perpendicular to the direction of the beam. If the beam is horizontal, the plane in which the particles rotate is vertical. In strong light, this plane stands somewhat outside the focus of the rays, and then the orbit along which the particles move may remain stable over long periods of time. In one experiment no change was noticed over a period of 24 hours.

The orbit remains constant so long as the light itself remains constant. If the vessel is shifted while the beam keeps its position the brightly illuminated orbit keeps its place relative to the beam, and the movement of the particles along it remains unaltered.

However, as soon as the beam is lowered or placed at another angle, the rotating particles follow suit in such a way that they always rotate around the beam. Again if the beam remains horizontal but its intensity is altered, the circular orbit moves either to the right or to the left, i.e., either away from the focus of the rays or towards it. Increase the intensity of the light and the brilliant ring wanders away from the focus: reduce the intensity and it moves towards the focus. Fig. 1 shows a continual migration of the brightly shining orbit towards the left where the focal plane must be imagined to lie outside the picture. In this case during the photographic exposure the light was reduced by the contraction of a diaphragm. If you continue to weaken the light, the orbit passes through the focus to the other side of the beam and becomes unstable. Switch the light off completely and the dust falls to the ground.

Close inspection of the rotating ring reveals that the particles perform a twofold movement:

1. in a circular orbit around the beam;
2. in spirals around this orbit (see Figs. 2 and 3). We can visualise the resulting track if we think of the spiral of a heating element and bend its ends together so as to form a ring. Yet this is not all. The particles also spin round their own axis, so that their path often looks like a pearl necklace. In a high vacuum, the particles may revolve around themselves 4000 times per second.

For simplicity's sake, I have first described the orbit as circular, but sometimes, as we see from Figs. 4 and 5, the path is very complicated. In Fig. 4 the particles run, in about one-tenth of a second, towards the light in two large turns, and then back in 3–4 smaller turns. Fig. 5 shows an even more complicated pattern.

When the light is switched off, the dust falls to the bottom of the flask. But as long as the light shines, the strange gyrations continue. As yet nobody knows what force holds these little particles floating in the air, counteracting the action of gravity. It is possible to compute the centrifugal force in operation from the radius of the curved path and the speed of rotation. It may be up to forty or even seventy times greater than the gravitational force acting on the particle.

So far as photophoresis is concerned, Ehrenhaft's observations have been confirmed by others, and everybody agrees that they are rather odd. Critics emphasise the fact that the mysterious merry-go-round is not shared by all the dust particles but only performed by a few of them. It is difficult to see why only a few particles are selected. It has been suggested that the size of the particles might decide this, or that some dissymmetry might produce, in accordance with mechanical laws, both the rotatory and the

EHRENHAFT'S 'MAGIC CIRCLES'

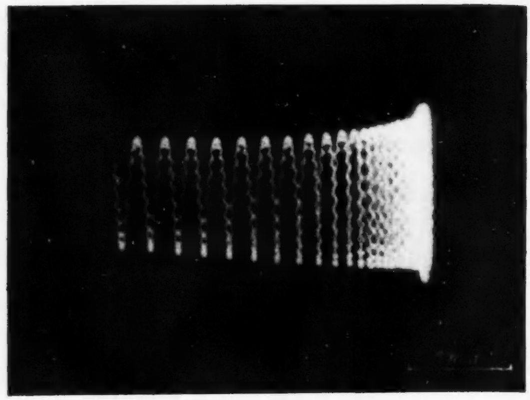
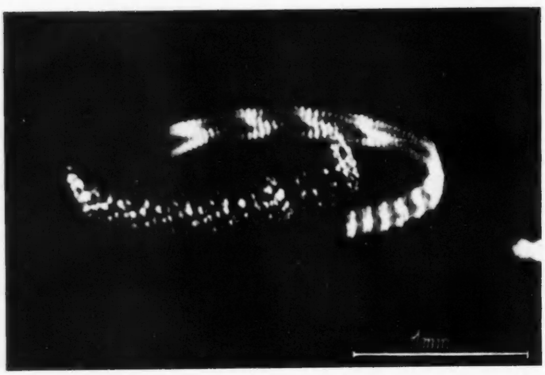


FIG. 1—During this experiment the beam is weakened by partial contraction of the diaphragm. The orbit approaches the focus, which is to the left (outside the picture). This picture was obtained, with graphite in air, at a pressure of 9 mm. mercury.



FIGS. 2 and 3.—Two particles in two-fold motion. (Graphite in argon: pressure. 2 mm. mercury.)

FIG 4.—This particle describes a complicated track, running regularly in two large windings towards the light and in three or four smaller windings back. (Graphite in argon; pressure, 2 mm. mercury.)

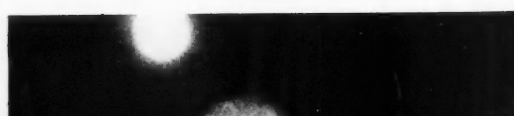


FIG 5.—This particle describes a complicated epicycle in a plane perpendicular to the ray. (Graphite in argon; pressure, 10 mm. mercury. Exposure, one-fifth of a second.)

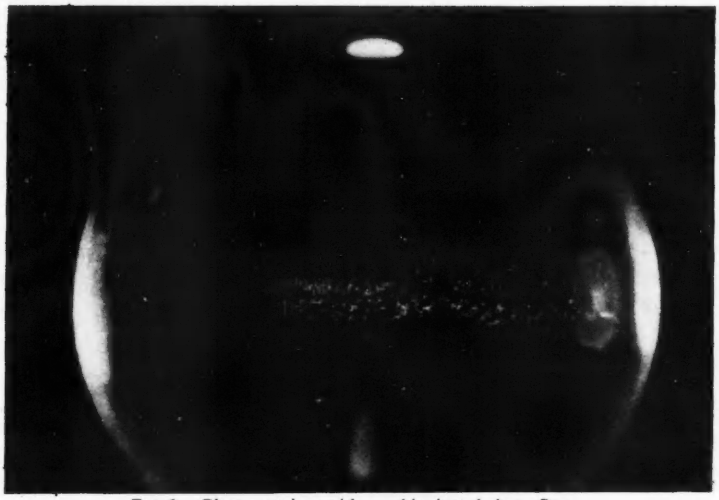


FIG 6.—Glass container with graphite just shaken. Sunlight horizontal from the right. Air pressure, 9 mm. mercury; exposure, one twenty-fifth of a second.

screw-like movement. But this is all mere conjecture. Professor Ehrenhaft has erected a very bold theoretical edifice on another series of observations, although hardly anyone apart from himself believes in these later theories. The following is a summary of his assertions: "In a homogeneous magnetic field one can observe, even with the naked eye, that material particles show a polarity similar to that in an electric field, inasmuch as some move towards the north, others towards the south pole. This movement, too, is screw-like. And here, too, the particles reverse their path whenever the field is reversed. Hitherto it was believed that bodies subjected to a homogeneous magnetic field are only turned into the north-south direction like the compass needle, but not moved from the spot. This is not correct.

"Magnetism like electricity dissociates matter into ions which in this case must be labelled north and south ions. Just as there are separate positive and negative charges, there are separate magnetic poles. A single magnetic pole in motion represents a magnetic current. Electricity and magnetism are not two phenomena, but only two aspects of a single phenomenon. A magnetically charged body rotates around an electric current and an electrically charged body rotates around a magnetic current."

"Permanent magnets are chemically active; they produce, in analogy to electrolysis, magnetolysis. While thus working, a magnet loses strength, as a working accumulator loses energy." "Light magnetises matter, as Morichini stated as far back as 1800 and as was also mentioned in a note by Faraday. As matter can rotate light, i.e., turn the plane of polarisation, thus light can also rotate matter."

There are only two points on which I should like to comment: (1) the magnetic pole, and (2) magnetolysis.

It is remarkable that Dirac demands the existence of isolated magnetic poles as a necessary consequence of the quantum theory, and I am told that every now and then an analyser of cosmic ray photographs ascribes the outlandish behaviour of some track to the presence of such a pole; but no definite conclusions can be drawn under so complex conditions. Anyway, according to Dirac, the production of a magnetic pole requires much more energy than that of an electric charge, whereas Ehrenhaft maintains that he obtains magnetic dissociation of matter at the same energy level as electric dissociation.

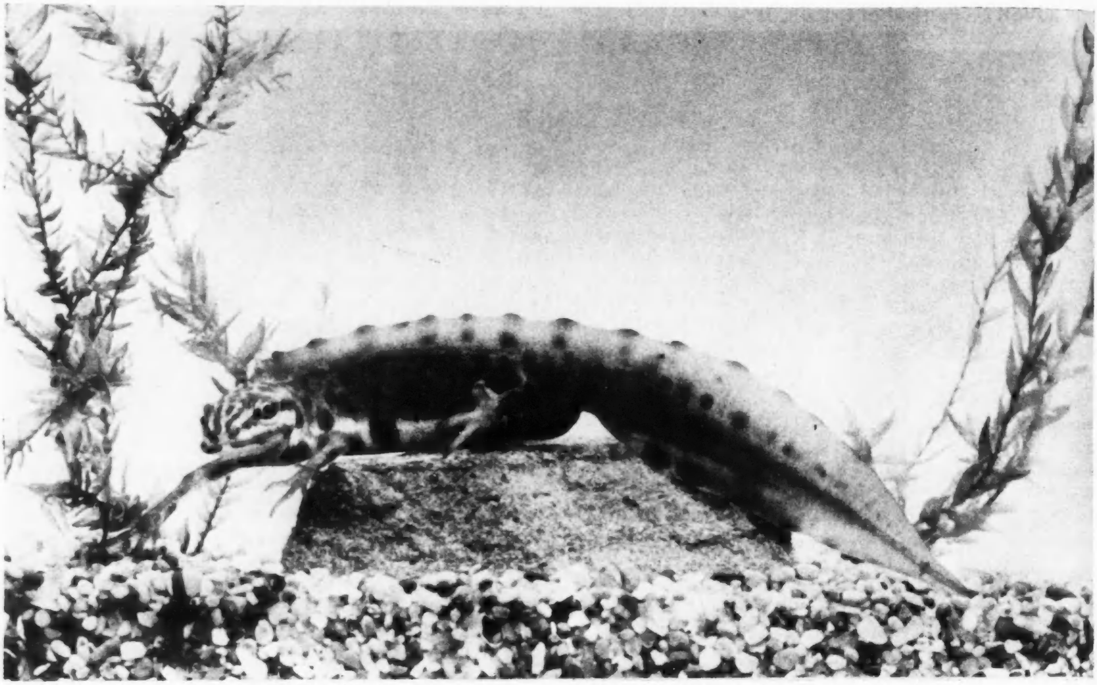
Experiments, some of which were undertaken in this country, to confirm the movement of particles in a strong magnetic field or the existence of magnetolysis gave negative or doubtful results. I understand that at the Technical University of Vienna a recent attempt to investigate the chemical action of permanent magnets "proved magnetolysis to be non-existent".

Professor Ehrenhaft's position in the academic world is not less odd than the phenomena which he describes. Now a man of 71, he has throughout his life opposed his fellow-physicists. For well over twenty years he was engaged in a controversy with Millikan concerning the existence or non-existence of 'subelectrons', i.e., particles containing an electric charge smaller than that of the ordinary electron. Even now Ehrenhaft believes in the reality of subelectrons and he refers to a paper by Yoshia Ishida, a collaborator of Millikan, who states that many experimental results had to be discarded, because they were from 10% to 15% 'out'. He reproaches the Millikan school for not having closely examined these disagreeing cases and not having investigated very tiny single particles as he did himself.

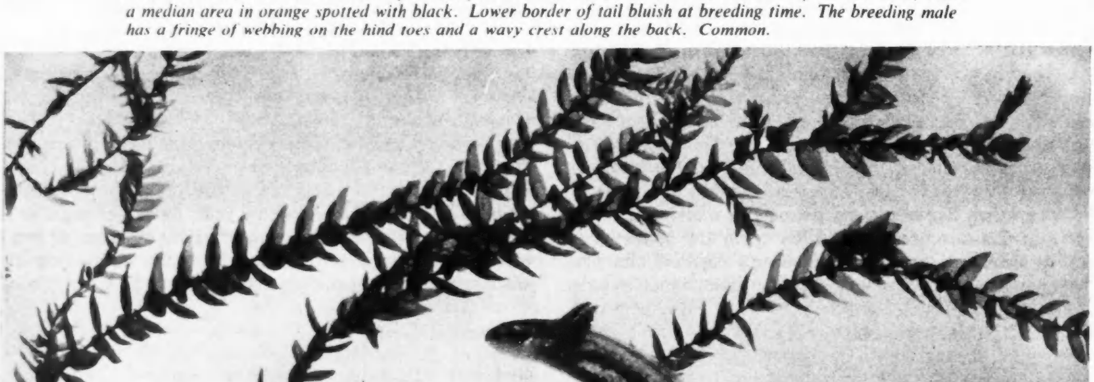
It is interesting that although so many atoms have been split in recent years and analysed by various methods, and although so many new particles have been discovered in cosmic rays and in other rays, the subelectron has not been accepted by science.

The prolonged and futile controversy about the subelectron has made the physicists angry and suspicious, and Ehrenhaft's later statements about magnetolysis and other activities of a magnetic current which, so far, have not been confirmed have increased their suspicion to such a degree that many firmly refuse to consider his results seriously, even when they appear to be correct.

Here, perhaps, we have the old story of crying "Wolf" all over again.



1. *Male SMOOTH NEWT (Triturus vulgaris) grows to about 4 in. Colour in the male varies from brown to olive above, covered with dark spots (stripes over the head); underneath, whitish to yellow or rose, with a median area in orange spotted with black. Lower border of tail bluish at breeding time. The breeding male has a fringe of webbing on the hind toes and a wavy crest along the back. Common.*



2. *Tadpole of SMOOTH NEWT. Newt larvae resemble the parents in shape, but are provided with feathery external gills. In this species, about 1½ in. long, colour is brown, sometimes reddish, the tail is well developed and the limbs slender and weak. Larvae of Smooth and Palmated newts are very similar.*

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The British Amphibia

ALFRED LEUTSCHER, B.Sc., F.Z.S.

(Photographs by Lionel Day, F.R.P.S.)

THE Amphibia are a class of vertebrate animals which were originally grouped with reptiles (or 'crawling' animals). But they are in fact far removed from true reptiles, as may be shown by an examination of their anatomy and life-history. A typical amphibian has a naked skin, which is smooth, moist or warty. It favours damp, shady places, and the young go through a larval stage which hatches from an egg laid in water. The transformation from larva to adult is called a metamorphosis.

A typical reptile on the other hand is covered with scales, favours drier surroundings and sunshine, and has no visible larval stage. The baby reptile is born from an egg in the mother's body, or one which is laid on land, and resembles its parent. Snakes, lizards, tortoises and crocodiles are examples of reptiles; frogs, toads, newts and salamanders are amphibians. The name of the second is derived from the Greek, and means 'a double life'.

Amphibia are often spoken of as the early ancestors of man, being the first land vertebrates. They arose from fish ancestors over 250 million years ago, and reached their greatest numbers and size in the late Carboniferous Period. when they lived in the extensive coal forests of those days. All were in appearance like huge newts, some reaching a length of ten feet. They are now extinct, and from their primitive stock arose the reptiles, then the birds and mammals, and finally man himself.

Modern Amphibia are poor in species, about two thousand being known.

Of these only eight occur in the British Isles, all of which are widespread on the continent of Europe. England has the greatest number, Scotland far less, and Ireland only two indigenous species.

Fossil evidence shows us that frogs, toads and newts lived in Britain prior to the Ice Age. Being cold-blooded animals they must have perished as the ice sheet advanced. With a return to warmer conditions a few managed to return before Britain became separated from the continent of Europe. Ireland was cut off earlier than England, and so received fewer species; St. Patrick was really not to blame.

Frogs

One of the commonest and most widespread amphibians in Britain is the Common Frog (*Rana temporaria*). On the Continent where other species are equally common it is called the Grass Frog or Brown Frog. It occurs all over our mainland and was introduced into Ireland in about 1796, and is now well established there in many counties. Its shape and long legs, which are adapted for swimming and jumping, are well known to most people. The skin is smooth and moist, and varies greatly in colour according to the surroundings. This is due to the movement of the pigment cells in the skin, called chromatophores, by which the frog can often match its background to a close degree.

Common frogs congregate in their breeding colonies in early spring, in ponds and water ditches. The male at this time has a dark pad on each thumb, with which to secure a tight hold on a mate. He grips her from behind in an embrace under the arm-pits. In the absence of a mate a male will sometimes grip a floating branch or passing fish. During mating the combined croaks of the males produce a dull, throbbing sound which comes from the inflated vocal sacs inside their throats. After about a week the female lays her cluster of dark eggs, up to 4000 in number, which are buried in a mass of jelly-like material. This protects the developing eggs and acts as an incubator. Spermatozoa ejected into the water by the male penetrate the spawn to fertilise each egg.

Baby tadpoles hatch in about a fortnight, and at first respire through plume-like outer gills. Later, inner gills are used, and they swim actively with their flattened tails, browsing on the soft plants, especially algae. Legs eventually appear, the tail dwindles in size, and final metamorphosis is reached in about three months after hatching. It is usually in June that a rain shower brings the froglets out of the pond in their thousands. The popular belief that it is raining frogs may have arisen from a sudden exodus of this type.

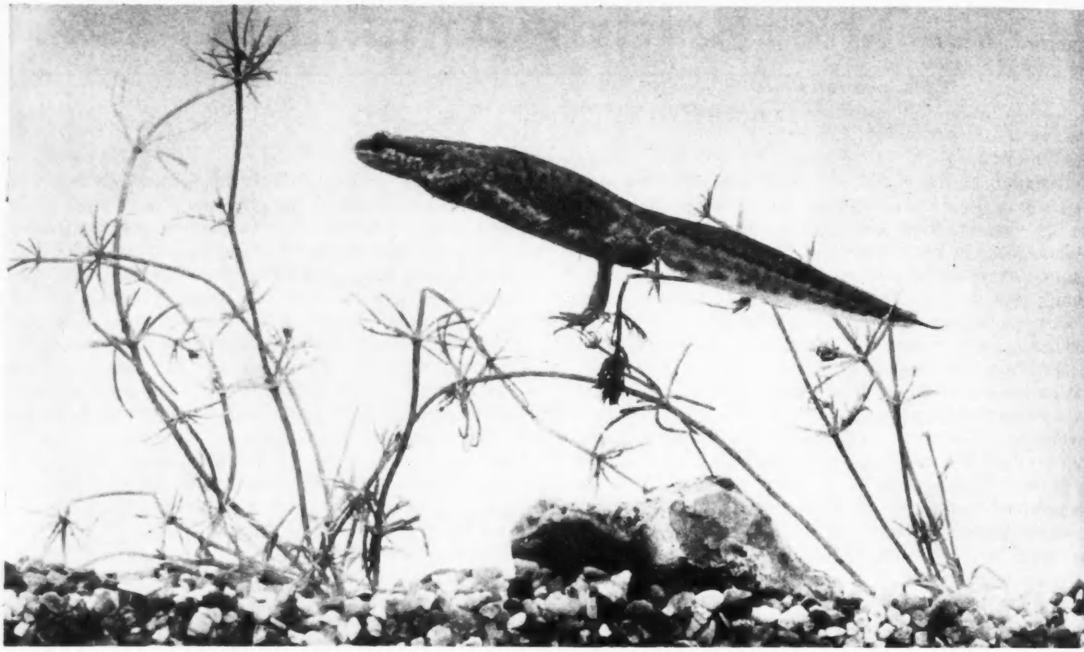
Spawning is completed by early March in south England; as early as December in Devon, and as late as April in Scotland have been reported—after which the adults prepare to leave the water. They seek out damp, shady places in fields, woods, ditches and gardens in which to hide; in such spots they are also able to avoid the hot sunshine which might otherwise dry up their skin and so kill them. Hence, too, they find an abundance of natural food, such as insects, crustaceans, molluscs and worms, which are rapidly caught on the frog's sticky tongue.

The chief enemies of frogs are pike, herons, snakes and hedgehogs. When caught by a snake a Common Frog will sometimes scream in distress. The tadpoles die by the million, being eaten by numerous kinds of water animals.

The Edible Frog (*Rana esculenta*) has been introduced into Britain from many European countries (e.g., Holland, Belgium, France, Germany and Italy) where it is found in great numbers in the dykes and marshes. It is caught and eaten as a table delicacy, the hind legs being served as an appetiser in a dish garlanded with spices.

As far back as 1837 it was liberated in the Foulmire Fen, Cambridgeshire, and later in parts of Norfolk. It is now largely extinct in its former haunts in the fens and meres of East Anglia, but by further introduction has established itself in parts of south-east England, especially in Surrey and Kent. It can now be seen (and heard) in the Richmond area, near London.

Edible frogs do not breed until May. They gather in water and pair off in the same way as common frogs, the females laying flat clusters of spawn containing up to 1000 straw-coloured eggs, usually among plants in shallow water. The tadpoles may grow to 3 inches in length. The adults remain in or near water after breeding, being very aquatic. They are fond of basking at the water's edge, or floating at the surface but will rapidly submerge if



3. *Male PALMATE NEWT (Triturus helveticus). The smallest British newt, it grows to about 3 in. Colour is variable, darker in the male, from brown to olive above with small spots; below, pale orange, usually with fine black spots. The spotting is much finer than in the Smooth newt. The pale-coloured throat is never spotted. Local but common.*

4. *Male CRESTED or GREAT WARTY NEWT (Triturus cristatus). Grows to about 5 in. The breeding male has a high, serrated dorsal crest and a silvery band along each side of the tail. At other times the crest is reduced to a mere fringe. Common.* (Inset) 5. *Tadpole of CRESTED NEWT. The external gills in this species are large and feathery; the body colour is a mottled brown. The tadpole is recognised by the conspicuous spots on the transparent tail, and the size—about 2 in.*

disturbed. Their movements are fast and sudden, and they are powerful swimmers.

The loud croak of the male was accurately described by Aristotle as a high-pitched *brek-kek-kek*, interspersed with a deeper *croax-croax*. In the Fens they became known as the 'Whaddon Nightingales'. On quiet summer nights a colony may be heard a mile away; the noise is produced by the two folds of skin in the angles of the jaws in the male, which are inflated with air to the size of a hazel nut.

The Marsh or Laughing Frog (*Rana ridibunda*) is a more recent introduction. In 1934 twelve specimens from Hungary were liberated into a garden pond by the owner, at Stone-in-Oxney, Kent. These have since multiplied in the dykes and canals of the Romney Marshes. The habits of the Marsh Frog compare closely with those of its much smaller cousin, the Edible Frog, but everything about it is on a larger scale. Both frogs catch and devour food under water, at the surface or at the water's edge. A Marsh Frog can even devour a small mammal or nestling bird; it is capable of leaping a distance of five feet, and it can outswim a man. It is the largest frog in Europe.

A full chorus of Marsh Frogs may keep a whole village awake; and residents in the area occupied by this species in Britain have complained about the noise, which to a country dweller on the Continent is a normal background to his sleep. The name 'Laughing Frog' (from *ridibunda*) describes its call, which is similar to that of the Edible Frog.

Toads

The two toads in Britain may be distinguished from the frogs by their squat bodies, shorter legs, and dry warty skins. Their life-histories are very similar. The Common Toad (*Bufo bufo*) has a wide distribution over the mainland, but is missing from Ireland. It breeds about a month after the Common Frog, usually in early April in south England. The males fight strongly for possession of a female, sometimes clinging to her body in large bundles of as many as a dozen. The female lays a high number of eggs—up to 7000—in two long strings which are twined among the water plants as she moves about in deeper water. The tadpoles are blackish, with rounded tips to their tails, whereas frog-tadpoles are brownish and have pointed tails. They metamorphose in about three months.

The 'homing' instinct of toads is strongly developed, and they will make for the same pond year after year, ignoring others on the way. A mass movement in spring may result in many deaths where the migrants cross a highway. After breeding they leave the water to look for shelter in woods, gardens and waste ground. An individual will often hide under a certain stone, log or flower-pot, to which it returns with regularity each morning.

Compared with frogs, toads are slow and clumsy. They can survive in much drier surroundings, and they move chiefly at night. The Common Toad is a friendly creature and is easily tamed; many people keep one as a pet. It will respond to an owner's call, and even take food from the fingers.

The Natterjack or Running Toad (*Bufo calamita*) has a local distribution in Britain, preferring areas of sand and light soil, especially near the coast. In England it is found in small colonies in various counties, including Hampshire, Surrey, Kent and Lancashire. It is largely absent from Wales and Scotland, and is restricted to County Kerry in Ireland.

Because of its very short legs the Natterjack cannot hop, and instead runs over the ground in short rushes. It is not over-fond of water, but it is a good climber and digger, often forming burrows in the soil. The breeding period is prolonged, from March into the summer months, so that tadpoles in all stages of development may be found in the same pond. The female lays her twin strings of eggs—up to 4000, which lie alternately in the jelly—in shallow water. The young develop rapidly and may leave the water in two months' time. At night the high-pitched croak of the male can be heard some distance away.

Toads live on a similar diet to frogs, and like frogs they catch their prey with a rapid flick of the tongue. They are rarely molested by enemies because of a bitter fluid which oozes from the skin when this is irritated; it is in fact doubtful whether any animal, except a snake, will eat a toad.

Newts

Newts are tailed amphibians related to the salamanders. The tail, unlike that of frogs and toads, is retained throughout life. Their shape resembles that of lizards, with which they are sometimes confused, though there is no need for this error since newts, which are amphibians, have naked skins whereas lizards are reptiles and covered in scales.

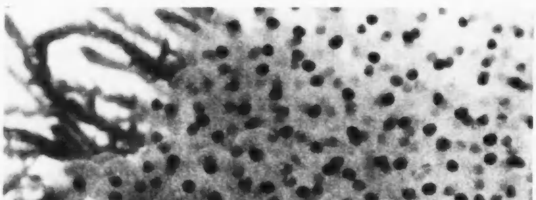
The three British species of newts are closely related and have very similar habits. They are found in ponds and ditches in early spring and have commenced breeding by April. At this time the male of each species develops a crest along the back and tail; this is used in a peculiar act of courtship, which can easily be watched in the aquarium. A male will approach a female and perform a kind of dance, which consists of arching the back, rising on the toes and curving the tail forwards, meanwhile flickering the tip with a rapid motion. After such preliminaries the male deposits the spermatozoa in a small whitish packet, called the *spermatophore*, near the female. She moves over this and picks it up with the lips of the cloaca; the spermatozoa pass into her body, and at intervals reach the oviducts to fertilise the eggs. This process provides a very unusual case among animals of internal fertilisation without coition.

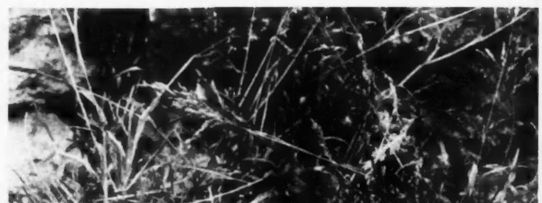
From April until well into midsummer the females lay their eggs singly, here and there, among the water plants: a leaf is usually cupped in the hind feet and folded around the egg, which adheres to it by its jelly-like covering.

The baby newt hatches in a few days, closely resembling the parent in shape but having feather-like external gills. It remains in water as a larva for about three months, feeding on minute animal life. In some cases, probably where development is late, it may overwinter as a larva, but normally the metamorphosed young leaves the water by late summer at about the same time as its parents.

On land the newts shelter beneath stones, logs and vegetation. They emerge after rain or at night to seek and catch small creatures like insects, worms, slugs and woodlice. Prey is snapped up with the mouth and dealt with according to size.

The Smooth Newt (*Triturus vulgaris*), often called the 'water eft', is our commonest species, and found all over





6. *COMMON TOAD (Bufo bufo). This toad differs from the common frog by its shorter limbs, more squat body and rough, usually dry, skin. Snout more rounded and toes less webbed than in the frog. Common.*

7. *NATTERJACK (Bufo calamita). The species grows to 2½ in. The soft skin has flattened warts, and is a greenish brown to olive in colour, marked with darker areas and with a pale yellowish stripe along the back. Legs are very short, and used for digging and running.*

8. *Female COMMON or GRASS FROG (Rana temporaria). A specimen resting under water beside the mass of spawn she laid the day before. The jelly has absorbed water and is now swollen to many times the original size.*

9. *Female EDIBLE FROG (Rana esculenta). The head is more pointed and the eyes more dorsal and prominent than in the common frog.*

10. *MARSH or LAUGHING FROG (Rana ridibunda). A female specimen from Romney. Sizes up to 5 in. in body length have been recorded. Very local in S.E. England.*

11. *A dyke in the Romney Marshes, Kent, the home of the British colony of the Marsh Frog (Rana ridibunda).*

Britain. It occurs in Ireland where it is called the 'Mankeeper'. It is missing from higher altitudes in Scotland and Wales, and parts of the western peninsula of England. Smooth newts are frequently caught by schoolboys in nets and on worms tied to cotton, the captures being referred to as 'kings' and 'queens' to distinguish the sexes. This is the *least* aquatic of British newts.

The Palmate Newt (*Triturus helveticus*) is our smallest newt, and in many respects the prettiest. It is widespread, but local on the mainland; it is often found at high altitudes. It is now known to be far more common than was formerly believed, because of a close resemblance to the Smooth Newt with which it was often confused. In the West Country, Wales and the entire west of Scotland it is the most abundant species. It is absent from Ireland.

The Crested Newt (*Triturus cristatus*), which is also called the 'Warty Newt' and the 'Triton', is our largest species. It occurs throughout Britain, but is missing from Ireland as well as Cornwall and parts of Wales. It is the most aquatic species, and in some ponds will stay in water all the year round.

Hibernation

For about six months in the year the British amphibians are forced into hibernation. Being cold-blooded their body temperature drops with the approaching cold weather, and by the end of October they have fallen into a torpid sleep, hidden away in some safe winter retreat. Wherever possible the frogs choose the mud and debris at the bottom of ditches and ponds, managing somehow to survive in an almost lifeless state. Newts will do the same and both these and frogs have sometimes been found frozen in the ice. Occasionally they hibernate on land, like toads, which never enter water. (The Common Toad chooses some sheltered spot—people often find it in their cellars or outhouses—and the Natterjack buries itself in the soil.)

All return to water in the spring—some are there already—except the immature which have no such desire, since maturity in these amphibians is not reached until the third or fourth year. Hibernation is not always a continuous state in these islands, and a mild spell of weather will sometimes bring the amphibians out of their hiding places.

Amphibians sometimes produce what may be called the 'Peter Pans' of the water world—they fail to mature. Enormous tadpoles have been found, as well as fully grown newts still bearing gills. This is thought to be due to some abnormality of the glands. Albinism also occurs, in which the amphibian is entirely white, sometimes with pink eyes.

Much has still to be learnt about the habits and lives of British amphibians. Because of the ease with which they may be kept in captivity—newts in the aquarium and frogs and toads in enclosures called vivariums—many naturalists and animal lovers have discovered that there can be much instructive research in an entertaining pastime. Amphibians have proved of great value to science and medicine and are well-known educational subjects in the laboratory and classroom.

The Bookshelf

The Science of Heredity. By J. S. D. Bacon. (Thinker's Library. London, Watts & Co., 1951, 191 pp., 3*s.* 6*d.*)

THIS small book of 191 pages endeavours to deal with the subject of heredity in such a way that the general reader can in twelve short chapters get an accurate idea of such important aspects as the mechanism of heredity, the functions of genes and chromosomes, the determination of sex, the impact of genetics on the life of man and other topics.

The author admits that he has had no specialised training or research experience in genetics. There are quite a number of small books which try to explain heredity in simple terms. Some of them are good, especially if they are written by specialists with a flair for simplicity. But most are not good. Yet, this book is not one of the worst of the small books; it is more accurate than most of them, though the statement that more genes are known in man than in any other mammal is not true, since we certainly know much more about the mouse.

The treatment of heterosis, of sex determination, and of quantitative characters is weak and must produce fog in the mind of the reader. The author does not seem to know that genes in the heterozygous phase may be advantageous over the two homozygous phases, even if the recessive itself is harmful. Heterosis thus may be in some cases a selection effect in which optimum combinations of heterozygotes have been preserved. The harmful results of self-fertilisation are thus most probably due to the fact that many genes are put into the homozygous condition to produce *combinations* which have previously not been exposed to the sieve of Natural Selection. The chapter on sex-determination which is dealt with in 19 pages is lamentably weak. To realise its fuzzy poverty it should be compared with the scholarly chapter in Waddington's *Introduction to Genetics*.

There is a chapter entitled "Arguments Against Genetics", which contains *no* arguments against genetics.

An important error is to assign the idea of progeny testing to the early part of this century, whereas, progeny testing was understood as early as 1826 by Le Couteur, not to mention the pre-Mendelian sugar beet breeding of Vilmorin, which owed its success to this very progeny test.

This book in common with some other recent works attempts to stress the practical plant breeding achievements of the Lysenko School of workers in the U.S.S.R. It is worth while noting that the orthodox methods of plant breeding were used in the Soviet Union from 1920 to 1940, and that during this period the same miraculous results were claimed for the old methodology as are claimed for the new—*if it is new!* The achievements of the former period were certainly very considerable, and they could be seen and confirmed by workers from other countries. If the practical achievements of recent times are really as impressive as those of the earlier period this may rather be due to the efficiency of the propaganda machine than to the methodology employed.

S. C. HARLAND.

Australian Shells. By Joyce Allan, F.R.Z.S. (Melbourne, Georgian House; published in Britain by Phoenix House, 1950, 470 pp., 60*s.*)

AUSTRALIA has extraordinarily rich molluscan fauna, and this volume by the Curator of Shells of the Australian Museum at Sydney aims at presenting popularly the commoner shells from the whole of Australia. This it does successfully and with a wealth of illustration: e.g., over 30 species of *Chiton* (Coat-of-Mail shells) are figured in line drawings. There are 44 beautiful plates, many in colour. The book is sufficiently detailed to make it as valuable to scientists as to amateur naturalists and collectors. What wouldn't one give for a similar book about British mollusca!

Cytology and Cell Physiology. Edited by G. H. Bourne. (London, Oxford University Press, 1951, pp. 524, 50*s.*)

THIS, the second edition of *Cytology and Cell Physiology* (first published in 1942), should be read by all students of the cell, whatever their line of approach to the subject. There is such a wealth of new information in this latest edition that it deserves to be considered as a new book. In fact so much prominence is given to recent research that the title has become outdated: the book is not an exhaustive treatise on cytology but rather a record of advance in the study of selected problems within this field.

The balance of the book has been improved by the incorporation of new articles on microscopy (in the widest sense), histogenesis in tissue culture and cytology viewed from an evolutionary standpoint (in an unusual sense). Moreover there are short critical discussions of freeze-drying and centrifugal fractionation methods which are most valuable in view of the extensive use being made of these methods at the present time. Nuclear cytology, on the other hand, is given rather scanty treatment and the book is unbalanced in this respect.

As is inevitable with books of composite authorship, there is some overlapping, and some discordancy of opinion on subject matter common to more than one author: hence the book reads somewhat like a symposium volume. For the advanced research worker this is stimulating, though disconcerting for the beginner about to enter the field.

Simple Experiments in Biology. By Cyril Bibby. (London, Heinemann, 2nd ed., 1950, pp. 216, 8*s.* 6*d.*)

This work now appears in its second edition in an illustrated form. It should be very useful to teachers without specialised training who desire to use experiments needing no expensive apparatus yet covering a large part of the field of biological studies. There is a very practical form of classification enabling experiments suitable for certain topics, or related to particular species as they may become available to be turned up quickly. Rather more quantitative work would have increased still further the educational value of this book. There is a concluding chapter dealing with various laboratory techniques, aquarium management, and the use of the microscope.

M.H.C.

Men Against the Desert. By Ritchie Calder. (London, Allen & Unwin, 1951; 186 pp., 12*s.* 6*d.*)

IT was probably an excellent notion on the part of Unesco to commission a populariser of science to go out and make a report on Desert Research. And Mr. Ritchie Calder is to be congratulated on winning the attention of many thousands of students of all types.

Viewed purely as a work of graphic descriptive journalism, *Men Against the Desert* is far from being contemptible. It is true that the sustained reading of chapters written in a style designed for brief descriptive articles is apt to lead to a cloying sensation, but, taken in small doses, this skilful piece of eye-witness reporting does attract the attention. Considered as a contribution to the science of agriculture, or to the furtherance of food-production for the dangerously increasing millions of the earth's population, the book is of less value. Scientific reporting, to be of real help, must induce a feeling of confidence—confidence in the author's thorough knowledge of his subject, in the accuracy of his facts, in his grasp of the problem in hand. Here, the very glibness of the writing, the very skill in portraying the characters who cross the author's path, the fashionable use of Americanisms and occasional bouts of slang, all tend to create an impression of superficiality, and this impression is not lessened by the number of minor inaccuracies which even a cursory inspection will bring to light. Some of the transliterations of Arabic words are distinctly unusual.

Still, if Mr. Calder's facile pen succeeds in awakening even a few people to the fact that there *is* such a thing as a Desert Problem, his journey will not have been in vain.

L. R. MUIRHEAD.

Population Genetics and Livestock Improvement. By I. M. Lerner. (London, Cambridge University Press, 1950, pp. 342, 30*s.*)

THE application of genetics to the problems of the animal breeder has, on the whole, been rather slower in this country than in the United States. Written by one of the leading research workers in the field, this book is the first presentation of the subject as a formal scientific discipline. Although it deals in detail only with the improvement of egg production in poultry, it is actually written in a very general manner so that it can be easily read by those interested in other animals. As it raises more questions than it settles, it requires in its readers a fair knowledge of genetics and some acquaintance with modern statistical

methods. "The audience primarily addressed is one consisting of investigators, teachers, and advanced students of genetics in relation to breeding," and to these it can be highly recommended.

ALAN ROBERTSON.

Natural History of Ireland. By R. L. Praeger. (Collins, London, 1950, pp. 350, 3 figs and 1 map. 25*s*.)

DR. PRAEGER, the doyen of Irish naturalists, carries his many years and his great knowledge lightly, so that, in a book built on his own work and crowded with additional facts taken from many other authors, he finds plenty of opportunity for those light touches which reveal his lively mind. To the general reader, the first hundred pages or so will be of great interest. They set out a broad picture of the natural history of Ireland, illustrated by the history, geography and ecology of the country, widened by comparisons with the fauna and flora of Great Britain and other parts of the northern hemisphere. The rest of the book contains a brief but adequate survey of the groups of Irish plants and animals. This part of the book, which, without skilful authorship, would have been no more than a dull catalogue, is made easy to read by the liberal introduction of notes of biological interest. Post-war difficulties may have hindered a final revision of the text, and the elimination of some repetitions. This is a small matter in a book which will certainly stimulate naturalists, not only in Ireland but also in Great Britain, to seek for answers to some of the many unsettled questions which the author leaves to the naturalists of the future. B. BARNES.

Voyages to the Moon. By Marjorie Hope Nicolson. (Macmillan, New York, 1948, pp. 297, 8 plates, 20*s*.)

IF one ignores the somewhat too elaborate literary style, this is a most intriguing book whose principal effect on the reader will probably be to add many items to that list of works of fiction and romance which "I must find time to read some day". It has also a more serious use, since it traces, chiefly through the medium of literature, the effects of certain scientific discoveries on the human mind and particularly on the imagination. Briefly its object is to show (*a*) the Copernican theory and (*b*) the general progress of science which made human flight attainable, fired the imagination of romantically minded scientific men and scientifically minded literary men, and inspired them to consider what men would meet when they found means of voyaging in space. Attention is concentrated on the seventeenth and eighteenth centuries, but an epilogue gives some consideration to later writers. The main cosmic voyages are summarised with a wealth of humour, and the sources of their scientific or pseudo-scientific elements sought for diligently and often found. The text can be read for pure enjoyment, or with the aid of a 30-page annotated bibliography, used as a basis for further research. Miss Nicolson has added another success to her series of works on the effects of science on literature. S. LILLEY.

Scientific Autobiography and other Papers. By Max Planck. With a memorial address by Max von Lane. Translated from the German by Frank Gaynor. (Philosophical Library, New York, 1949, pp. 192, with portrait, $3.75.)

BESIDES the 40-page autobiography, this volume contains essays on "Phantom Problems in Science", "The Meaning and Limits of Exact Science", "The Concept of Causality in Physics", and "Religion and Natural Science".

Max Planck was a very great scientist, and these documents help to reveal how the mind of a scientist works. They are of the utmost significance, and will provide useful material for some future historian. To take a specific example, the autobiography begins by saying that Planck's original decision to devote himself to science arose from his realising—presumably at the age of 17 or earlier—"that the laws of human reasoning coincide with the laws governing the sequences of the impressions we receive from the world about us; that, therefore, pure reasoning can enable man to gain an insight into the mechanism of the latter". If this statement is true, his youthful mind must have been so different from that of any other budding scientist, that the subject should have received pages of explanation, instead of one paragraph. In fact this is much more likely to be a later rationalisation of thoughts and emotions not clearly remembered, and so really gives information about the state of Planck's mind at the date (not stated in the volume) when the autobiography was written.

However, when its limitations are realised, the volume remains worth reading, whether for the descriptions of men like Kirchhoff and Helmholtz, under whom Planck studied, or for the revelations about Planck himself that come from his attempts to state and to solve philosophical problems. One point becomes abundantly clear: to be a great scientist, one does not need to be a great—or even competent—philosopher! S. LILLEY.

The Antarctic Problem. By E. W. Hunter Christie. (London, Allen & Unwin, 1951, pp. 336, 25*s*.)

STRATEGIC considerations and scientific research have brought the Antarctic Continent into prominence. And in one region of this vast territory—the Falkland Islands Dependencies—the two are at present inseparable. This sector comprises roughly the Graham Land Peninsula and its neighbouring seas and the area stretching south of it to the Pole. Though Britain regards the Dependencies as her possession, both Argentine and Chile challenge this claim. All three nations have scientific bases there. To portray faithfully how the current situation has come about, the author has delved into Antarctic history right from the days of the earliest exploration. The result makes fascinating reading—far more intriguing than perhaps the title of the book conveys. Just as absorbing as the tales of courage and heroic endeavour is the story of scientific research in this region. So far scientists have no idea whether or not the continent consists of two vast islands divided by a strait buried beneath thousands of feet of solid ice. But they have gleaned much evidence to imply that Graham Land is a continuation of the South American Andes. Linking the two is a submerged mountain chain, visible in places as the barren islands lying off the northern end of the peninsula. Geological study has given substance to this belief which is one argument used in Argentine's claim.

Politics aside, the Dependencies offer great attractions for the geologists and mineralogist. The rock formations and fossil remains afford an idea of Antarctica in early times, and already tend to point to the theory that it was once joined by land bridges not only with South America, but also Australia and South Africa, and perhaps a sunken continent in the Pacific. The tremendous ice-cap has so far prevented a detailed accumulation of knowledge of the mineral resources. Possibly there is coal in Alexander I Land. Copper is known to exist appreciably in Graham Land, where there are traces of low-grade silver and gold-bearing ores, manganese and molybdenite. As yet no uranium or other radio-active minerals have come to light but, as the author suggests, in such an extensive region it would be astonishing if these and other important minerals were not present in what—under normal conditions—would be regarded as commercial quantities. But how to penetrate the ice to locate and exploit them is another question. The author deals with varied aspects of Antarctica; for instance, the animal life. Writing officially, Mr. Christie has produced a capital work.

DOUGLAS LIVERSIDGE.

Seismicity of the Earth and Associated Phenomena. By B. Gutenberg and C. F. Richter, Seismological Laboratory, California Institute of Technology. (Princeton University Press, U.S.A.; London: Geoffrey Cumberlege, Oxford University Press, 1949; 273 pp., including 34 illustrations, 80*s*.)

THE authors of this handsome volume are well-known authorities on seismic phenomena. This book of roughly 162 pages, with 32 maps, may be regarded as being in two parts—the first deals with the classification of shocks, the energy liberated during earthquakes, discussions relating to the various seismic areas of the world, etc., and the second, of tables of all earthquakes, giving particulars of date, class, magnitude, region, etc. This volume is essentially a reference book which will find a place on the shelves of most scientific libraries which are consulted by geological, geographical and geodetic students and by engineers concerned with the erection of heavy buildings in earthquake areas.

It contains interesting information about the structure of the earth as disclosed by the different rates of travel of seismic waves through to its core. The authors are confident that their conclusions are quite reliable and that there are marked discontinuities in the rates of travel of the seismic waves below depths of 30–60 kilometres, after a depth of 1000 kilometres and at a depth of 2900

kilometres. Geologists recognise a molten nickel-iron core, which is met with at a depth of 2900 kilometres and which is surrounded by a solid layer of metallic sulphides about 1900–2000 kilometres thick.

The greatest of the great earthquakes liberate energy far in excess of the most violent volcanic eruptions, such as the explosion of Krakatoa, which, in turn, exhibited far greater force than any of the atomic bombs so far exploded.

CYRIL S. FOX.

Birds in Action. By Eric Hosking and Cyril Newberry. (London, Collins, 1949; 128 pp., 16*s*.)

British Waders in Their Haunts. By S. Bayliss Smith. (London, Bell, 1950; 172 pp., 21*s*.)

THESE two books by bird photographers differ so radically in their approach to their subject that it is an advantage to be able to review them together. The first is a book whose implications few amateur ornithologists will view with equanimity, for they will conclude that ornithology, as exemplified in this latest work of our best-known team of bird photographers, is moving farther and farther from the orbit of the ordinary person. For although to outward appearance this is another book of fine bird photographs, it is in effect a brilliantly illustrated, semi-technical treatise on the application of high-speed photography to creatures in motion. This is not to say that it does not add to our knowledge of wild birds, especially of the mechanics of their flight, and their feeding habits; but at the same time, most of the text and the majority of the captions emphasise details of photographic technique, rather than the beauty and interest of the subjects themselves. This is a pity, since many of the wonderful photographs are of outstanding ornithological interest.

The book contains some twelve pages of text, devoted principally to an explanation of the working and technique of high-speed flash photography, as used normally and as adapted by the authors, with the help of Dr. P. S. H. Henry, to their own particular purpose. Of greater interest, probably, are the notes on the use of the apparatus in the field, its limitations and its advantages. In the actual photographs, however, the reader is amply rewarded. For these do provide a really extraordinary series of views of birds, mostly small passerines, on the wing and at the nest, feeding their young or attacking other (stuffed) birds placed in strategic positions by the photographers. There are 70 of these fine photographs in black and white and 8 in colour, and it is perhaps with the latter group, which are made possible only by the use of this flash equipment, that the most worthwhile results, from the ordinary reader's point of view, are apparent.

None the less, there must surely be many (the present reviewer is unashamedly among them) who turn with relief to the few delightful shots of waders, standing in comely dignity on sandbank and shore, and feel that here at least are birds in their natural home; it is just this type of photograph, in which birds are seen in a normal situation, which makes the second of the new books so successful and so full of delight for the amateur. It deals, admittedly, with birds of a single group, and that one of the least known in Britain, the waders. Most of them are species which appear here only as winter visitors or passage migrants, and even then most are confined to the coasts and estuaries. These birds are unfamiliar even to many bird watchers, but after reading Bayliss Smith's book, the waders can no longer seem so remote or so hard to distinguish the one from the other. Not only does he bring them close to us, as a result of a technique of bird-watching (not of applied electronics) which must have been worked out with infinite patience and not a little hardihood; he also displays them to us in photographs so excellent, and with a text so charming, that we can feel we already know these birds and have added everything but the actual sight of them to our experience.

Bayliss Smith has used a smaller camera than most workers; he emphasises that a telephoto lens is a *sine qua non*, but so it is for most much more ordinary work; he uses a hide, in most cases a simple *ad hoc* affair made on the spot. What his work must demand, it is true, is the willingness to sit and wait, and to work at times in bad weather and under conditions which would keep most of us indoors.

Several other features mark this book as something of an event for the ornithologist. It contains, for example, specimens of the work of several of the best Dutch photographers which show some of the waders, now lost as breeding birds to Britain, at home in their breeding haunts. Moreover, unlike many bird photographers, Bayliss Smith can write. The book is excellently produced; besides the descriptive chapters, it has three most useful plates of waders in flight by Basil Laker; a neat supplement in which the major features of the waders are tabulated and described; maps of distribution and breeding . . . but alas, no index!

P. B. C.

Isaac Newton. By E. N. da C. Andrade. (London, Max Parrish, 1950, pp. 111 with 8 plates and 5 line illustrations, 6*s*.)

THIS new series of 'Personal Portraits', consists of works by distinguished contemporary authors who have been invited to the pleasant task of composing 'the biography I would most like to write'. A fortunate and happy choice has produced for the general reader this excellent little book on Newton by Professor Andrade.

While everyone has heard of Newton, few other than the scientifically equipped are aware of his great achievements, which, as our author rightly says, have changed the current of human thought "so that all that comes after him bears evidence of his spirit". Beginning on a personal note, Professor Andrade tells his readers of his earliest knowledge of Newton's work and how he later came "to understand something of Newton's achievement", showing that Newton was "one of the great heroes of humanity" and one who by common consent among men of science still holds the supreme place in their company.

Thereafter the main facts of Newton's early life and his education are narrated from his birth at Woolsthorpe on Christmas Day, 1642, to his graduation in Trinity College, Cambridge, in 1665. We then come to the great discoveries made by Newton at Woolsthorpe, during an enforced vacation in 1665–66 when the University of Cambridge was closed on account of the Great Plague then raging in London, the infinitesimal calculus, the composition of white light and the law of gravitation. These advances and their subsequent development are skilfully explained in simple words without the use of technicalities and explained against the background of contemporary thought, so that the intelligent general reader without scientific training (and even scientists are general readers in science other than their own) is enabled to understand and appreciate what Newton actually did and how he brought about a revolution in men's outlook on the world around them.

The chapter on "The System of the World", explaining the chief advances and results of the *Principia*, is a model popular exposition of the achievements of the mighty mind which composed that immortal work. This and, indeed, the whole book, brief though it is, maintains the great tradition of the popularisation of scientific knowledge established at the Royal Institution, which is specially associated with the names of Davy, Faraday, Tyndall and Bragg, and now admirably followed here by their latest successor.

Professor Andrade has a deep understanding, not only of Newton's achievements, but also of his personality—his sensitiveness, his simplicity, his generosity, his dislike of argument and controversy, withal his strange and baffling nature: and he has here given us a vivid thumb-nail sketch of one of the most extraordinary figures in human history.

D. MCKIE.

The Use of Geography. By Professor Frank Debenham. (English Universities Press, London, 1950, pp. 206, 6*s*.)

IN this book, the first of a new series, *Teach Yourself Geography*, Professor Debenham lucidly explains the modern concept of geography and its uses. Not only are the aims and structure of the subject clearly defined, but the ways in which we may all appreciate more fully the complexity of our surroundings, and life in this troubled post-war age, are clearly indicated. Written essentially for the student it is, however, a book with a wide appeal; we may look forward to the remaining volumes of this series from the Cambridge School.

F. A. HENSON.

The Principles of Scientific Research. By Paul Freedman (London, Macdonald, 1949, pp. 222, 15*s*.).

MR. FREEDMAN is head of a large industrial research laboratory, and into this book he has distilled the essence of his experience in the knockabout world of industrial research. It contains a wealth of

friendly advice and wise counsel for the young graduate who is about to pursue a similar career and also for the managers who will be his employers, whom Mr. Freedman politely refers to as the Patrons of science.

It is a pity, in view of the excellence of this aspect of the book, that Mr. Freedman has chosen such an awe-inspiring title; perhaps in an attempt to justify his choice, he has inserted three introductory chapters dealing very cursorily with the history of science and its relations with society and with philosophy. One wishes, in fact, that the author had written a kind of scientific autobiography and left the reader to determine for himself the extent to which 'fundamental principles' could be deduced from the facts before him. In spite of this, however, the book makes excellent reading and can be warmly recommended to both of the classes of reader to which it is addressed.

C. G. A. H.

Biology: an introduction to medical and other studies. By P. D. F. Murray. (Macmillan, London; pp. 600, 381 illustrations, 25*s*.)

In a field already fairly well covered, a new textbook of intermediate biology is required to justify its existence by offering something that the others haven't got, or by treating familiar subjects in a novel way. On both counts this book justifies itself, the former being unavoidably reflected in the relatively high price.

It is well known that in most intermediate biology syllabuses Botany takes second place to Zoology. Prof. Murray's book reflects this tendency: the botanical sections, although adequate, are obviously the work of a zoologist. A botanist, one feels, could not bring himself to separate the Algae and the Fungi by nearly five hundred pages, whatever the advantages of the arrangement from other points of view. It is indeed from the taxonomic standpoint that the book is chiefly to be criticised.

A textbook, in addition to outlining general principles, has to impart a good deal of detailed information. In this respect Prof. Murray's book is notably free from sins of commission, except that one does not feel entirely happy about a chapter on the coelom and metameric segmentation. In the matter of omission, however, there is a little more to say. No mention is made of *Monocystis* (which is in the London 1st M.B. syllabus) and no account is given of the anatomy of the fern rhizome. One feels, too, that some account of recent work on the circulation of the frog should by now be appearing in the textbooks, and that a more critical attitude might have been taken in view of the present state of genetical and evolutionary theory.

Comment of this kind, however, would be ungenerous were attention not drawn to the book's good qualities. The main text is well arranged, and is thoroughly readable. A comparative treatment is used wherever possible, while the illustrations are both plentiful and excellent. The sections on embryology and general physiology, in particular, deserve special mention. Where he deems it an advantage the author does not hesitate to bring in matter that is "outside the syllabus", the outstanding example being three chapters on the taxonomic position and evolution of man.

On balance, therefore, one may say that Prof. Murray's book compares very favourably with others of its kind. It should, however, be pointed out that, while the book meets the requirements of most intermediate examinations in general biology, it is not suitable for the student who is reading Botany and Zoology as separate subjects.

R. P. H.

An Introduction to Laboratory Technique. By A. J. Ansley. (London, Macmillan, 2nd ed., 1950, pp. 279, 16*s*.)

This is the second edition of a book first produced in 1938. It is a volume containing all the essential 'know-how' on the manipulation and assembly of laboratory apparatus.

The book contains a wealth of information, some of it very curious and intriguing; how many people know, for instance, that 'a spider can usually be persuaded to spin a thread by tilting him off a card'? The production of mirrors, the soldering of many sorts of metal, the graduation of glass surfaces, the working of glass (including the sealing-in of electrodes) are all described at length. There is an important chapter on the care of equipment and another on lutes, cements and solvents. There are tables of wire gauges, etc. The use of modern materials has been added to this new edition. In fact, while Mr. Ansley sticks to his own subject he is a dependable and knowledgeable guide. (It is to be doubted, however, whether he ought to give any theoretical information without careful checking. A statement of his on page 253, for example, about Ampère's swimming rule, does not make sense.)

This book would be very useful for anyone starting in his teens as a laboratory assistant, teachers who have to construct their own apparatus without technical assistance, and amateurs (of whom one hopes there are still many) who experiment for the love of it.

C. L. Boltz

LETTER TO THE EDITOR

THE PAY OF SCIENCE TEACHERS

Sir:

Could your correspondent "Rama" (March 1951 issue) clarify some of his views on teachers? It is apparent that he dislikes us, with a fierce, unreasoning dislike, but could he, for example, decide whether our day lasts from "after 9 a.m." to "before 4.30 p.m.", or not—since he states "no-one would suggest that the teacher's labours are limited to the time spent in front of a class". He cannot have it both ways. I suggest that if he will rid his mind of cloudy emotionalism and think as befits a good honours degree man, he will realise that his first requirement in coming to a decision on this question is more information about science masters, their salaries, their duties and their schools. I would be glad, with the willing assistance of my wife and my colleagues, to supply him with this information, but he must first emerge from his cloak of anonymity—I would prefer him to pay a visit rather than indulge in correspondence.

Meanwhile, here are a few points, facts and not mere prejudice:

1. The salary of a grammar school master has not risen since 1938. To be the equal of the 1938 salary in purchasing power, the present scale should have a maximum of £860. (Disregarding the rise in prices since 1949!!) The new, increased Burnham Scale offers a maximum of £726 for a four-year-trained graduate.

2. The grammar schools today have sixth forms considerably larger than in 1938. There is, therefore, considerably more work of an advanced nature to be carried out.

3. It is evident that the Burnham Scale is below the "market price" for science graduates. Schools cannot fill vacancies even when special allowances are added to the basic scale. I can supply details of actual cases to "Rama" if necessary, and in any case the university appointments boards could supply him with details of schools requirements *not* met during the past few years. Ministry of Education statistics are misleading on this point as a one-year-trained non-graduate is a teacher to the Ministry indistinguishable from an honours graduate.

4. His completely unsubstantiated charge of inefficiency is a reflection on the Ministry of Education Inspectorate as well as on the teachers.

5. Finally, and ignoring sneers about pensions—ours are contributory, of course—let us have this question of salaries considered from the angle of the parents: do they wish their children to have good teachers or underpaid, harassed, disgruntled misfits? Quality is something that must be paid for, and in recent years the quality of work in the grammar schools has been in grave danger, if not actually deteriorating. The remedy is simple and obvious and has already been applied to technical colleges—*it is to pay higher salaries to those teachers engaged in work at advanced levels—i.e. in the grammar schools.*

I am quite prepared to supply "Rama" with details of actual cases of staffing difficulties, hours of work, etc., provided he drops his pseudonym and agrees to treat this matter as a hard-headed administrator should—in the light of the situation as it exists in the schools today—not thirty years ago.

Yours etc., G. F. West,

Chief Science Master,

Great Yarmouth Grammar School.

Far and Near

Films in the Festival of Britain

THE story of British achievement in the field of film production cannot be told through the medium of any one exhibit or on the screen of a single cinema. For this reason, the British Film Institute, which is responsible for organising the film side of the Festival, has followed the policy of working in close co-operation with all branches of the film industry in order to secure the widest possible showing of outstanding British films throughout the country during the period of the Festival.

Festival Film Productions are producing a special feature film for the Festival, *The Magic Box*, which will tell the story of William Friese-Greene, the British inventor and pioneer in films.

Special film weeks are being organised by exhibitors in most of the main centres during the Festival. It is also expected that a number of new and outstanding feature films will be released this year.

In the South Bank Exhibition itself, a specially designed building, *The Telecinema*, takes its place among the other Festival Pavilions as a centre for demonstrating new and experimental techniques as well as realist and documentary films of which Britain is an acknowledged leader in world production. Also—for the first time—big-screen television will be included in the regular cinema programme, bringing to audiences at each performance a sense of up-to-the-moment actuality—what is going on in other parts of the Festival Site, along with interviews in the cinema itself and demonstrations of the novel equipment it contains. Then, reaching out into the future, the Telecinema will present to its audiences a new kind of film sound track, using the latest magnetic medium and causing the sound to issue at will from any part of the screen or from the back or ceiling of the auditorium. Coupled with this 'sound in space' will be a 'picture in space'—a stereoscopic movie. The method of achieving this effect involves projection, through polarising filters, of two complementary images on the screen representing the left and right eye views. The audience will be provided with special glasses which separate out the two images. This is a considerable advance over the older system which involved the use of coloured filters.

These films will be the first films ever produced combining three-dimensional or 'stereophonic' sound and three-dimensional picture in colour. A spectator entering the Telecinema during the performance might, for instance, see a plane plunging right out from the screen, while, as it flashes overhead, the roar of the engines will transfer itself from the screen to the back of the auditorium, just as if it were physically passing through the cinema.

A new design of big-screen television projection is now being constructed by Cinema-Television Ltd., and the programmes will originate from camera equipment supplied by Marconi Wireless Telegraph Ltd.

In addition to the equipment being installed in the Telecinema, special development has gone into the production of the stereoscopic film. Technicolor Ltd. have played a leading part, by supplying a special stereoscopic device incorporating two Technicolor cameras and collaborating with the British Film Institute on the development of special printing techniques. Stereoptics Ltd. and James A. Sinclair & Co. have contributed to the production of a second stereoscopic camera which will be used for recording events occurring during the Festival for presentation in the Telecinema.

Pavlov's Anniversary

THE 15th anniversary of the death of the great Russian physiologist, Ivan Pavlov, has been widely commemorated in the Soviet Union. The Academy of Medical Sciences of the U.S.S.R. held a special meeting which heard a report by Pavlov's pupil, Professor Mikhail Ussyevich, now head of the Institute of Physiology of the Academy of Medical Sciences.

"Academician Pavlov devoted over sixty years of his life to science," said the speaker. "His works on the role of the nervous system in the functioning of the heart and his works on digestion are of tremendous importance. But his greatest achievement is his teaching on the cerebrum and the higher nervous activity."

The meeting also heard reports by the heads of the departments of the Academy which showed the wide application of Pavlov's teaching in medicine and made it clear that his teaching has served as a basis for achieving major successes in many branches of neurology and neurosurgery, in curing a number of diseases and in particular high blood pressure.

Meetings dedicated to the memory of Pavlov were held by the Society of Physiologists, Biochemists and Pharmacologists and the Institute of Physiology in Leningrad.

Floating Laboratory for Korea

Two ships of the U.S. Navy designed to protect the health of large groups of civilians are now operating in Far Eastern waters. The latest to arrive is a floating epidemic control laboratory designed to prevent the spread of contagious diseases among Korean civilians and refugees.

Another U.S. Naval vessel has been conducting research and medical examinations in the South Pacific Islands since 1948.

The laboratory ship in Korean waters will move into infested ports to wipe out epidemics before they can spread. The U.S. Defence Department, explaining one great advantage of a laboratory ship over present facilities in Korea, said that serious diseases such as typhus cannot be accurately diagnosed by physical symptoms alone. Laboratory blood tests must be made. The new floating laboratory will substantially reduce the time normally required for tests when blood specimens have to be sent to laboratories in Japan.

The U.N. Unified Command in Korea had reported previously that typhus was present in the Communist armies in Korea.

India's need for Research Experts

REQUESTS have been received by Unesco from India for technical assistance under the United Nations million dollar scheme to help under-developed areas. India has asked for Unesco's help in establishing a Bibliographical Centre and a Western Higher Technological Institute. Unesco has also been asked to appoint a number of research experts to fill various scientific posts. Their jobs will be to organise the work of their departments and to inaugurate programmes of research and training. A highly qualified specialist is required in each of the following eight fields: Plastics and high polymers (National Chemical Laboratory, Poona); Low-temperature physics (National Physical Laboratory, New Delhi); Heavy Electrical Engineering (Indian Institute of Technology, Kharpur); Mechanical Engineering (Indian Institute of Technology, Kharpur); Hydraulics (Indian Institute of Technology, Kharpur); Concrete Research (Central Waterpower, Irrigation and Navigation Commission Laboratory); Photo-elastic studies (Central Waterpower, Irrigation and Navigation Commission Laboratory); Navigation (Central Waterpower, Irrigation and Navigation Commission Laboratory); Palaeo-botany (to be Director of Birbal Sahni Institute, Lucknow).

These posts are of one to three years' duration and carry tax-free salaries of between £2000–£3000 a year. Suitably qualified experts may obtain further information from the National Commission for Unesco, Ministry of Education, Bryanston Square, London, W.1.

New Director of the Chemical Research Laboratory

DR. D. D. PRATT, O.B.E., acting director of the Chemical Research Laboratory, Teddington, has been appointed Director of the Laboratory.

American Chemical Society's Diamond Jubilee

CHEMISTS and chemical engineers from all parts of the world are celebrating 1951 as the Diamond Jubilee Year of the American Chemical Society. A two-week World Chemical Conclave in New York and Washington in September will climax the year's programme.

The Conclave, which promises to be one of the most significant gatherings of chemists and chemical engineers ever held, will be opened by the 75th anniversary meeting of the American Chemical Society in New York from September 3 to 7. This Jubilee meeting will be followed by the 12th International Congress of Pure and Applied Chemistry in New York and the 16th Conference of the

International Union of Pure and Applied Chemistry in New York and Washington. Delegates from more than 30 countries will attend.

B.O.T. Information and Documents Unit

As from April 1, 1951, the Technical, Information and Documents Unit, which for a number of years has been attached to the Board of Trade, becomes part of the Information Services of the Department of Scientific and Industrial Research. For the present the Unit will remain in Lacon House, Theobalds Road, W.C.1, where it will continue to hold at the disposal of industry the large collection of unpublished documents, interest in which has recently revived on account of the valuable information they contain on the production and use of substitute materials. A small Technical Section is available to assist with the selection of material to meet specific needs, whilst a reading room is provided for those wishing to make a detailed study of drawings and documents. Alternatively photocopies can be supplied at moderate charges. T.I.D.U. will be represented at the British Industries Fair on Stand W. 2 at Earls Court and Stand B. 425 at Castle Bromwich, where full information can be obtained about the service provided.

Night Sky in May

The Moon.—New moon occurs on May 6d 01h 35m, U.T., and full moon on May 21d 05h 45m. The following conjunctions with the moon take place:

May				
2d 18h	Jupiter in conjunction with the moon	Jupiter	3°	S.
4d 22h	Mercury ,,	Mercury	5°	S.
9d 17h	Venus ,,	Venus	3°	S.
16d 22h	Saturn ,,	Saturn	4°	N.
30d 10h	Jupiter ,,	Jupiter	4°	S.

In addition to these conjunctions with the moon, Venus is in conjunction with Uranus on May 17d 05h, Venus being 2·1°N.

The Planets.—Mercury is a morning star, rising at 4h 20m, 3h 45m, and 3h 15m, on May 1, 15, and 31, respectively, but is too close to the sun to be observed. Venus is an evening star, setting at 23h 05m, 23h 20m, and 23h 25m, at the beginning, middle, and end of the month, respectively, and is visible for some hours after sunset, stellar magnitude −3·6. The visible portion of the illuminated disk varies from 0·74 to 0·62 during the month and a small telescope will show this phenomenon similar to the waning moon. Mars, in conjunction with the sun on May 22, is too close to the sun throughout May for observation. Jupiter rises in the early morning hours, an hour before sunrise on May 1 and two hours before sunrise on May 31. Saturn does not set until the early morning hours, at 3h 35m, 2h 40m, and 1h 35m, on May 1, 15, and 31, respectively, and is easily recognised a little N.E. of β Virginis. The planet appears to have a small westward movement until the end of the month, which can be noticed by comparing its positions on May 1 and 30 with reference to β Virginis, to which it gradually draws closer, but after May 30 it appears to recede from the star, though this will not be obvious for about a fortnight unless observers use some instrument to measure the angular distances between the star and the planet.

It may be noticed that a list of conjunctions of the planets with the moon is given each month, and a few words of explanation of this phenomenon may be necessary. When a planet is in conjunction with the *moon* this implies that the two bodies have the same *right ascension*, though conjunctions of planets with the *sun* refer to *longitude*, but the important thing to remember is that the two bodies make a close approach at the hour stated, and in the case of a conjunction with the moon, it is not necessarily the closest approach. Many of the conjunctions take place during daylight and hence, though the moon may be visible to the naked eye, the planet may not be. This does not happen on May 16d 22h, when both the moon and Saturn will be visible, unless clouds intervene.

Fox Talbot, Father of Modern Photography

As a contribution to the Festival of Britain, Kodak Limited are staging an exhibition to show why William Fox Talbot, a British scientist of genius, may be justly described as the "Father of Modern Photography". By a comprehensive display of photographic equipment, original prints, notebooks and letters, this exhibition will show how Fox Talbot's experiments, carried out over 100 years ago, formed the basis of modern photography. Many of these exhibits, brought from the Fox Talbot home at Lacock Abbey in Wiltshire by kind permission of Miss M. T. Talbot, have not been available before. Visitors to the exhibition will be amazed to find how far he advanced not only towards modern pictorial photography but also towards technical and industrial applications of photography.

The exhibition shows among other interesting things: the evolution of the box camera; printing papers; document copying; mass reproduction of photographs; reproduction of photographs by photo-mechanical means; filters; flash photography; photography by invisible radiation. In each case the present-day equivalent will be displayed alongside the Fox Talbot original. For instance, Fox Talbot's experiment in flash photography at the Royal Institution in 1851 will be demonstrated and contrasted with striking examples of modern flash photography.

A Triangular Research Aeroplane

First details have been released of the Fairey 'Delta' One F.D.1 research aircraft, which has successfully made its first flight.

The Fairey Aviation Company Limited advocated some years ago a programme of research based on the delta configuration, which was supported by the Ministry of Supply, and the present announcement is the outcome of several years of concentrated effort.

Pilotless radio-controlled scale models have been successfully flown and now the first full-scale aircraft has been flown by the Company's Chief Test Pilot, Group Captain R. G. Slade.

The F.D.1 Research Plane

No performance figures may yet be given, but externally evident features may be commented upon. The F.D.1, so called because its wing plan form resembles the Greek letter delta, is a small single-seater monoplane mounted on a retractable tricycle undercarriage and powered by a Rolls-Royce Derwent gas turbine. The overall length is 26′ 3″ and the wing span is only 19′ 6½″.

The F.D.1 is a tailless aircraft designed for important research work with revolutionary possibilities in the design and operation of fighter aircraft. It will be noticed, however, that a small tailplane and fixed wing-tip slots are fitted as a precautionary measure for the early flight testing. Air brakes and wing-tip parachutes are fitted to deal with flight emergencies and a central drogue type parachute is installed at the rear end of the fuselage to relieve the wheel brakes during the pull-up after landing.

Flying controls take the form of 'elevons' and rudder. The 'delta' configuration gives the low drag characteristics necessary for very high-speed flight, together with a light stiff wing structure and, what is most important, stowage space for fuel, armament, etc., within the profile of the wing. Needless to say, the conclusions favouring the delta configuration were only arrived at after a most extensive aerodynamic research programme, which has been occupying the Company's attention for many years.

Sergei Vavilov (1891–1951)

The recent death of Sergei Vavilov, President of the Russian Academy of Sciences, was remarkable for the manner in which political capital was made out of the occasion. Thus *Pravda* editionalised as follows: "Academician Sergei Ivanovich Vavilov, President of the Academy of Sciences of the U.S.S.R., Deputy of the Supreme Soviet of the U.S.S.R., eminent scientist and outstanding State and public figure, untiring fighter for advanced Soviet science, ardent propagandist for the great ideas of Communism, has died at the height of his creative powers." According to *Soviet News*, published by the Russian Embassy in London, "The working people of Moscow on January 27 paid their last tributes at the lying-in-state of Sergei Ivanovich Vavilov. At 10 a.m.

(Moscow time) the public were admitted to the Hall of Columns of the Trade Union House. Funeral music by Tchaikovsky, Beethoven and Chopin was played. Every three minutes the guard of honour was changed."

The Central Committee of the Communist Party was heavily represented in the guard of honour, as was the Red Army. Science was represented by Academicians Lysenko, Bykov and Muskhelishvili.

The last guard of honour was mounted by Academician I. P. Bardin, Vice-President of the Academy of Sciences of the U.S.S.R., A. F. Gorkin, Secretary of the Praesidium of the Supreme Soviet of the U.S.S.R., M. Yasnov, Chairman of the Moscow City Soviet, and Academicians A. I. Oparin, A. V. Palladin, D. V. Skobeltsyn and A. V. Topchiev. At 3 p.m. N. S. Khrushchev, Secretary of the Central Committee of the C.P.S.U. and of the Moscow Regional Committee of the C.P.S.U., together with members of the State Funeral Commission, lifted the coffin and bore it out of the Hall of Columns.

In his funeral oration N. S. Khrushchev said: "Academician Vavilov was always closely connected with the people and served them faithfully, giving all his knowledge and strength to the cause of Communist construction in our country, to the cause of the Party of Lenin and Stalin."

Academician Bardin spoke at the meeting on behalf of the Council of Ministers of the U.S.S.R., Academician Skobeltsyn on behalf of the Academy of Sciences of the U.S.S.R., and Mikhail Yasnov, Chairman of the Moscow City Soviet, on behalf of the working people of Moscow.

After the funeral meeting the coffin was lowered slowly into the grave. Three rifle volleys were fired and the National Anthem of the Soviet Union was played.

Born in Moscow in 1891, he entered Moscow University in 1909 and became a student of P. N. LEBEDEV. On graduation he was offered a post in the Physics Department of the university, but refused this offer and left, together with other scientists, as a protest against police persecution of leading scientists.

Under the Soviet regime he did much research on luminescent materials, and was twice awarded a Stalin Prize.

To preserve his memory the U.S.S.R. Council of Ministers has decreed that: Vavilov's name shall be conferred on the Moscow Institute for Physical Problems and the State Optical Institute; all his research papers are to be published by the Academy of Sciences: a Vavilov Gold Medal is to be awarded each year for outstanding physical research; four post-graduate Vavilov scholarships in physics are to be instituted. His widow has been given a pension and a special grant of 75,000 roubles.

Readers of DISCOVERY will recall that Sergei Vavilov had a very distinguished elder brother—NIKOLAI IVANOVITCH VAVILOV. A great geneticist who studied under Bateson, he revolutionised our ideas of the origins of cultivated plants. His position as the leader of Russian plant-breeding research was usurped by LYSENKO, and NIKOLAI VAVILOV died in disgrace during the last war. So far as we have been able to sift the evidence it appears that his death occurred in a concentration camp in the Far North of Russia.

BISRA's First Five Years

A BRIEF report of the work carried out by BISRA (British Iron and Steel Research Association) during its first five years of operation has been published and is available, free, from 11 Park Lane, London, W.1.

4000 Science Masters

MEMBERSHIP of the Science Masters' Association rose to 4080 in 1950, 1792 schools being represented; 164 of these schools are abroad. There are twelve active branches of the S.M.A. A new one was recently formed in Northern Ireland, being centred on Belfast.

The annual meeting of the S.M.A. Scottish Branch was held at Glasgow University from March 28 to 30. Included in the programme were seven new science films, including a U.S. colour film *The Gift of Green*, about the importance of photosynthesis. A visit was paid to the Loch Sloy Hydro-electric Scheme, which we featured in our December 1950 issue.

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